AQA Maths Mechanics 1

Past Paper Pack

2006-2015

General Certificate of Education
January 2006
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

MATHEMATICS **MM1B**
Unit Mechanics 1B

Monday 16 January 2006 9.00 am to 10.30 am

For this paper you must have:
- an 8-page answer book
- the **blue** AQA booklet of formulae and statistical tables

You may use a graphics calculator.

Time allowed: 1 hour 30 minutes

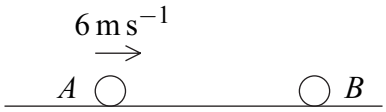
Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1B.
- Answer **all** questions.
- All necessary working should be shown; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, formulae may be quoted, without proof, from the booklet.

Answer **all** questions.

1 A particle A moves across a smooth horizontal surface in a straight line. The particle A has mass 2 kg and speed $6\,\mathrm{m\,s^{-1}}$. A particle B, which has mass 3 kg, is at rest on the surface. The particle A collides with the particle B.



(a) If, after the collision, A is at rest and B moves away from A, find the speed of B. *(3 marks)*

(b) If, after the collision, A and B move away from each other with speeds $v\,\mathrm{m\,s^{-1}}$ and $4v\,\mathrm{m\,s^{-1}}$ respectively, as shown in the diagram below, find the value of v.

(3 marks)

2 A particle P moves with acceleration $(-3\mathbf{i} + 12\mathbf{j})\,\mathrm{m\,s^{-2}}$. Initially the velocity of P is $4\mathbf{i}\,\mathrm{m\,s^{-1}}$.

(a) Find the velocity of P at time t seconds. *(2 marks)*

(b) Find the speed of P when $t = 0.5$. *(3 marks)*

3 (a) A small stone is dropped from a height of 25 metres above the ground.

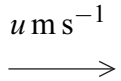
(i) Find the time taken for the stone to reach the ground. *(2 marks)*

(ii) Find the speed of the stone as it reaches the ground. *(2 marks)*

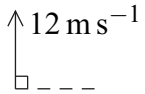
(b) A large package is dropped from the same height as the stone. Explain briefly why the time taken for the package to reach the ground is likely to be different from that for the stone. *(2 marks)*

4 Water flows in a constant direction at a constant speed of $u\,\text{m s}^{-1}$. A boat travels in the water at a speed of $12\,\text{m s}^{-1}$ relative to the water.

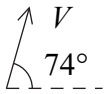
(a) The direction in which the boat travels relative to the water is perpendicular to the direction of motion of the water. The resultant velocity of the boat is $V\,\text{m s}^{-1}$ at an angle of 74° to the direction of motion of the water, as shown in the diagram.



Velocity of the water



Velocity of the boat relative to the water

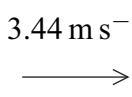


Resultant velocity of the boat

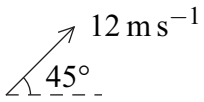
(i) Find V. *(2 marks)*

(ii) Show that $u = 3.44$, correct to three significant figures. *(3 marks)*

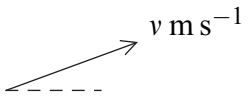
(b) The boat changes course so that it travels relative to the water at an angle of 45° to the direction of motion of the water. The resultant velocity of the boat is now of magnitude $v\,\text{m s}^{-1}$. The velocity of the water is unchanged, as shown in the diagram below.



Velocity of the water



Velocity of the boat relative to the water

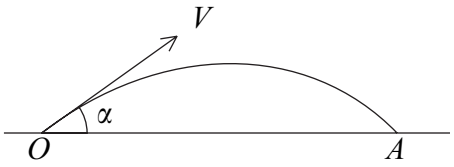


Resultant velocity of the boat

Find the value of v. *(4 marks)*

Turn over for the next question

5 A golf ball is projected from a point O with initial velocity V at an angle α to the horizontal. The ball first hits the ground at a point A which is at the same horizontal level as O, as shown in the diagram.



It is given that $V\cos\alpha = 6u$ and $V\sin\alpha = 2.5u$.

(a) Show that the time taken for the ball to travel from O to A is $\frac{5u}{g}$. *(4 marks)*

(b) Find, in terms of g and u, the distance OA. *(2 marks)*

(c) Find V, in terms of u. *(2 marks)*

(d) State, in terms of u, the least speed of the ball during its flight from O to A. *(1 mark)*

6 A van moves from rest on a straight horizontal road.

(a) In a simple model, the first 30 seconds of the motion are represented by three separate stages, each lasting 10 seconds and each with a constant acceleration.

During the first stage, the van accelerates from rest to a velocity of $4\,\text{m s}^{-1}$.

During the second stage, the van accelerates from $4\,\text{m s}^{-1}$ to $12\,\text{m s}^{-1}$.

During the third stage, the van accelerates from $12\,\text{m s}^{-1}$ to $16\,\text{m s}^{-1}$.

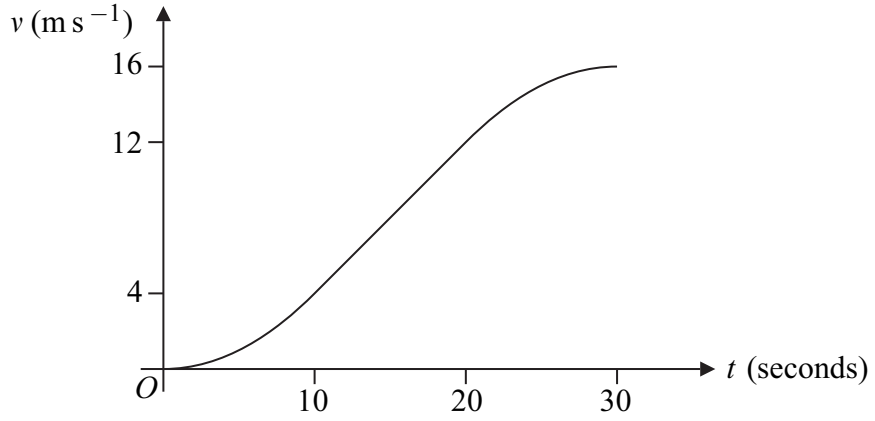
(i) Sketch a velocity–time graph to represent the motion of the van during the first 30 seconds of its motion. *(3 marks)*

(ii) Find the total distance that the van travels during the 30 seconds. *(4 marks)*

(iii) Find the average speed of the van during the 30 seconds. *(2 marks)*

(iv) Find the greatest acceleration of the van during the 30 seconds. *(2 marks)*

(b) In another model of the 30 seconds of the motion, the acceleration of the van is assumed to vary during the first and third stages of the motion, but to be constant during the second stage, as shown in the velocity–time graph below.

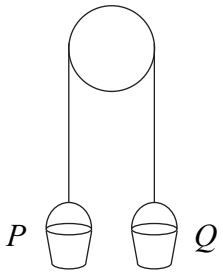


The velocity of the van takes the same values at the beginning and the end of each stage of the motion as in part (a).

(i) State, with a reason, whether the distance travelled by the van during the first 10 seconds of the motion in **this** model is greater or less than the distance travelled during the same time interval in the model in part (a). *(2 marks)*

(ii) Give one reason why **this** model represents the motion of the van more realistically than the model in part (a). *(1 mark)*

7 A builder ties two identical buckets, P and Q, to the ends of a light inextensible rope. He hangs the rope over a smooth beam so that the buckets hang in equilibrium, as shown in the diagram.



The buckets are each of mass 0.6 kg.

(a) (i) State the magnitude of the tension in the rope. *(1 mark)*

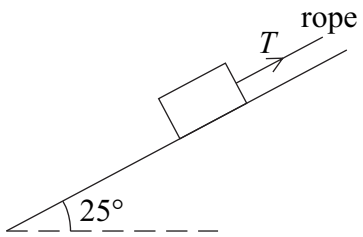
(ii) State the magnitude and direction of the force exerted on the beam by the rope. *(2 marks)*

(b) The bucket Q is held at rest while a stone, of mass 0.2 kg, is placed inside it. The system is then released from rest and, in the subsequent motion, bucket Q moves vertically downwards with the stone inside.

(i) By forming an equation of motion for each bucket, show that the magnitude of the tension in the rope during the motion is 6.72 newtons, correct to three significant figures. *(6 marks)*

(ii) State the magnitude of the force exerted on the beam by the rope while the motion takes place. *(1 mark)*

8 A rough slope is inclined at an angle of 25° to the horizontal. A box of weight 80 newtons is on the slope. A rope is attached to the box and is parallel to the slope. The tension in the rope is of magnitude T newtons. The diagram shows the slope, the box and the rope.



(a) The box is held in equilibrium by the rope.

(i) Show that the normal reaction force between the box and the slope is 72.5 newtons, correct to three significant figures. *(3 marks)*

(ii) The coefficient of friction between the box and the slope is 0.32. Find the magnitude of the maximum value of the frictional force which can act on the box. *(2 marks)*

(iii) Find the least possible tension in the rope to prevent the box from moving down the slope. *(4 marks)*

(iv) Find the greatest possible tension in the rope. *(3 marks)*

(v) Show that the mass of the box is approximately 8.16 kg. *(1 mark)*

(b) The rope is now released and the box slides down the slope. Find the acceleration of the box. *(3 marks)*

END OF QUESTIONS

General Certificate of Education
June 2006
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

MATHEMATICS **MM1A/W**
Unit Mechanics 1A

Tuesday 6 June 2006 1.30 pm to 2.45 pm

For this paper you must have:
- an 8-page answer book
- the **blue** AQA booklet of formulae and statistical tables

You may use a graphics calculator.

Time allowed: 1 hour 15 minutes

Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1A/W.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

Information
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Unit Mechanics 1A has a **written paper and coursework**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 A small stone is dropped from a high bridge and falls vertically.

(a) Find the distance that the stone falls during the first 4 seconds of its motion. *(3 marks)*

(b) Find the speed of the stone when it has been falling for 4 seconds. *(2 marks)*

2 A car travels along a straight horizontal road. The motion of the car can be modelled as three separate stages.

During the first stage, the car accelerates uniformly from rest to a velocity of $10\,\mathrm{m\,s^{-1}}$ in 6 seconds.

During the second stage, the car travels with a constant velocity of $10\,\mathrm{m\,s^{-1}}$ for a further 4 seconds.

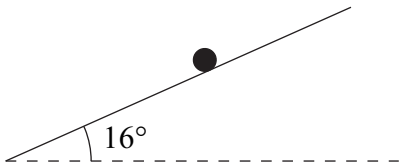
During the third stage of the motion, the car travels with a uniform retardation of magnitude $0.8\,\mathrm{m\,s^{-2}}$ until it comes to rest.

(a) Show that the time taken for the **third** stage of the motion is 12.5 seconds. *(2 marks)*

(b) Sketch a velocity–time graph for the car during the three stages of the motion. *(4 marks)*

(c) Find the total distance travelled by the car during the motion. *(3 marks)*

3 A stone rests in equilibrium on a rough plane inclined at an angle of 16° to the horizontal, as shown in the diagram. The mass of the stone is 0.5 kg.



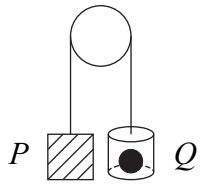
(a) Draw a diagram to show the forces acting on the stone. *(1 mark)*

(b) Show that the magnitude of the frictional force acting on the stone is 1.35 newtons, correct to three significant figures. *(3 marks)*

(c) Find the magnitude of the normal reaction force between the stone and the plane. *(2 marks)*

(d) Hence find an inequality for the value of μ, the coefficient of friction between the stone and the plane. *(2 marks)*

4 A block P is attached to a can Q by a light inextensible string. The string hangs over a smooth peg so that P and Q hang freely, as shown in the diagram.



The block P and the can Q each has mass 0.2 kg. The can Q contains a small stone of mass 0.1 kg. The system is released from rest and the can Q and the stone move vertically downwards.

(a) By forming two equations of motion, show that the magnitude of the acceleration of P and Q is $1.96\,\mathrm{m\,s^{-2}}$. *(5 marks)*

(b) Find the magnitude of the reaction force between the can and the stone. *(3 marks)*

5 The points A and B have position vectors $(3\mathbf{i} + 2\mathbf{j})$ metres and $(6\mathbf{i} - 4\mathbf{j})$ metres respectively. The vectors $\mathbf{i}$ and $\mathbf{j}$ are in a horizontal plane.

(a) A particle moves from A to B with constant velocity $(\mathbf{i} - 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. Calculate the time that the particle takes to move from A to B. *(3 marks)*

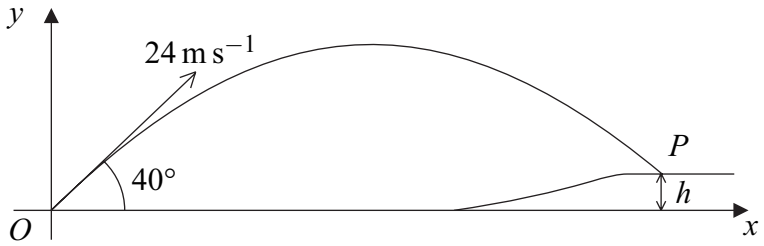
(b) The particle then moves from B to a point C with a constant acceleration of $2\mathbf{j}\,\mathrm{m\,s^{-2}}$. It takes 4 seconds to move from B to C.

(i) Find the position vector of C. *(4 marks)*

(ii) Find the distance AC. *(2 marks)*

Turn over for the next question

6 A golf ball is struck from a point O with velocity $24\,\mathrm{m\,s^{-1}}$ at an angle of 40° to the horizontal. The ball first hits the ground at a point P, which is at a height h metres above the level of O.



The horizontal distance between O and P is 57 metres.

(a) Show that the time that the ball takes to travel from O to P is 3.10 seconds, correct to three significant figures. *(3 marks)*

(b) Find the value of h. *(3 marks)*

(c) (i) Find the speed with which the ball hits the ground at P. *(5 marks)*

(ii) Find the angle between the direction of motion and the horizontal as the ball hits the ground at P. *(2 marks)*

7 Two particles, A and B, are moving on a smooth horizontal surface.

The particle A has mass $m\,\mathrm{kg}$ and is moving with velocity $\begin{bmatrix} 5 \\ -3 \end{bmatrix} \mathrm{m\,s^{-1}}$.

The particle B has mass $0.2\,\mathrm{kg}$ and is moving with velocity $\begin{bmatrix} 2 \\ 3 \end{bmatrix} \mathrm{m\,s^{-1}}$.

(a) Find, in terms of m, an expression for the total momentum of the particles. *(2 marks)*

(b) The particles A and B collide and form a single particle C, which moves with velocity $\begin{bmatrix} k \\ 1 \end{bmatrix} \mathrm{m\,s^{-1}}$, where k is a constant.

(i) Show that $m = 0.1$. *(3 marks)*

(ii) Find the value of k. *(3 marks)*

END OF QUESTIONS

General Certificate of Education
January 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

MATHEMATICS **MM1B**
Unit Mechanics 1B

Friday 12 January 2007 9.00 am to 10.30 am

For this paper you must have:
- an 8-page answer book
- the **blue** AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 30 minutes

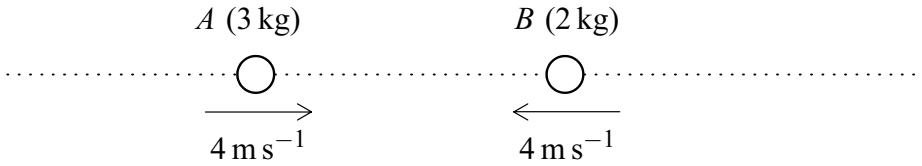
Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1B.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 Two particles A and B have masses of 3 kg and 2 kg respectively. They are moving along a straight horizontal line towards each other. Each particle is moving with a speed of $4\,\mathrm{m\,s^{-1}}$ when they collide.



(a) If the particles coalesce during the collision to form a single particle, find the speed of the combined particle after the collision. *(3 marks)*

(b) If, after the collision, A moves in the same direction as before the collision with speed $0.4\,\mathrm{m\,s^{-1}}$, find the speed of B after the collision. *(3 marks)*

2 A lift rises vertically from rest with a constant acceleration.

After 4 seconds, it is moving upwards with a velocity of $2\,\mathrm{m\,s^{-1}}$.

It then moves with a constant velocity for 5 seconds.

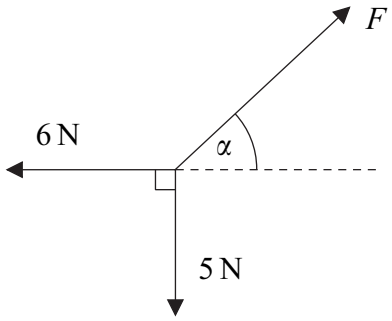
The lift then slows down uniformly, coming to rest after it has been moving for a total of 12 seconds.

(a) Sketch a velocity–time graph for the motion of the lift. *(4 marks)*

(b) Calculate the total distance travelled by the lift. *(2 marks)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 300 kg. Find the maximum tension in the cable during this motion. *(4 marks)*

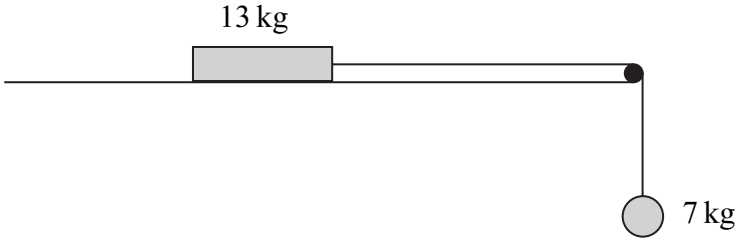
3 The diagram shows three forces which act in the same plane and are in equilibrium.



(a) Find F. *(3 marks)*

(b) Find α. *(3 marks)*

4 The diagram shows a block, of mass 13 kg, on a rough horizontal surface. It is attached by a string that passes over a smooth peg to a sphere of mass 7 kg, as shown in the diagram.



The system is released from rest, and after 4 seconds the block and the sphere both have speed $6\,\text{m s}^{-1}$, and the block has **not** reached the peg.

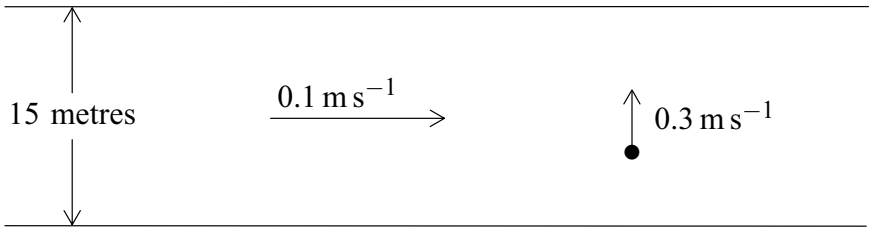
(a) State **two** assumptions that you should make about the string in order to model the motion of the sphere and the block. *(2 marks)*

(b) Show that the acceleration of the sphere is $1.5\,\text{m s}^{-2}$. *(2 marks)*

(c) Find the tension in the string. *(3 marks)*

(d) Find the coefficient of friction between the block and the surface. *(6 marks)*

5 A girl in a boat is rowing across a river, in which the water is flowing at $0.1\,\text{m}\,\text{s}^{-1}$. The velocity of the boat relative to the water is $0.3\,\text{m}\,\text{s}^{-1}$ and is perpendicular to the bank, as shown in the diagram.



(a) Find the magnitude of the resultant velocity of the boat. *(2 marks)*

(b) Find the acute angle between the resultant velocity and the bank. *(3 marks)*

(c) The width of the river is 15 metres.

(i) Find the time that it takes the boat to cross the river. *(2 marks)*

(ii) Find the total distance travelled by the boat as it crosses the river. *(2 marks)*

6 A trolley, of mass 100 kg, rolls at a constant speed along a straight line down a slope inclined at an angle of 4° to the horizontal.

Assume that a constant resistance force, of magnitude P newtons, acts on the trolley as it moves. Model the trolley as a particle.

(a) Draw a diagram to show the forces acting on the trolley. *(1 mark)*

(b) Show that $P = 68.4\,\text{N}$, correct to three significant figures. *(3 marks)*

(c) (i) Find the acceleration of the trolley if it rolls down a slope inclined at 5° to the horizontal and experiences the same constant force of magnitude P that you found in part (b). *(4 marks)*

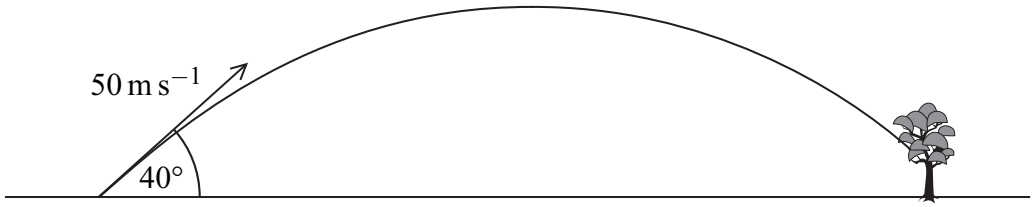
(ii) Make one criticism of the assumption that the resistance force on the trolley is constant. *(1 mark)*

7 A golf ball is struck from a point on horizontal ground so that it has an initial velocity of $50\,\mathrm{m\,s^{-1}}$ at an angle of $40°$ above the horizontal.

Assume that the golf ball is a particle and its weight is the only force that acts on it once it is moving.

(a) Find the maximum height of the golf ball. *(4 marks)*

(b) After it has reached its maximum height, the golf ball descends but hits a tree at a point which is at a height of 6 metres above ground level.



Find the time that it takes for the ball to travel from the point where it was struck to the tree. *(6 marks)*

8 A particle is initially at the origin, where it has velocity $(5\mathbf{i} - 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. It moves with a constant acceleration $\mathbf{a}\,\mathrm{m\,s^{-2}}$ for 10 seconds to the point with position vector $75\mathbf{i}$ metres.

(a) Show that $\mathbf{a} = 0.5\mathbf{i} + 0.4\mathbf{j}$. *(3 marks)*

(b) Find the position vector of the particle 8 seconds after it has left the origin. *(3 marks)*

(c) Find the position vector of the particle when it is travelling parallel to the unit vector $\mathbf{i}$. *(6 marks)*

END OF QUESTIONS

General Certificate of Education
June 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

MATHEMATICS **MM1B**
Unit Mechanics 1B

Tuesday 5 June 2007 1.30 pm to 3.00 pm

For this paper you must have:
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Advice
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Answer **all** questions.

1 A ball is released from rest at a height h metres above ground level. The ball hits the ground 1.5 seconds after it is released. Assume that the ball is a particle that does not experience any air resistance.

(a) Show that the speed of the ball is $14.7\,\mathrm{m\,s^{-1}}$ when it hits the ground. *(2 marks)*

(b) Find h. *(2 marks)*

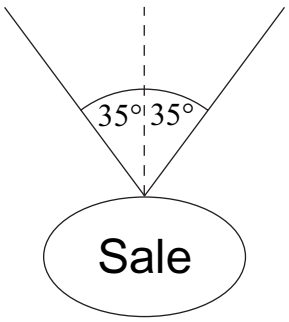
(c) Find the distance that the ball has fallen when its speed is $5\,\mathrm{m\,s^{-1}}$. *(3 marks)*

2 Two particles, A and B, are moving on a smooth horizontal surface. Particle A has mass 2 kg and velocity $\begin{bmatrix} 3 \\ -2 \end{bmatrix}\mathrm{m\,s^{-1}}$. Particle B has mass 3 kg and velocity $\begin{bmatrix} -4 \\ 1 \end{bmatrix}\mathrm{m\,s^{-1}}$. The two particles collide, and they coalesce during the collision.

(a) Find the velocity of the combined particles after the collision. *(3 marks)*

(b) Find the speed of the combined particles after the collision. *(2 marks)*

3 A sign, of mass 2 kg, is suspended from the ceiling of a supermarket by two light strings. It hangs in equilibrium with each string making an angle of 35° to the vertical, as shown in the diagram. Model the sign as a particle.

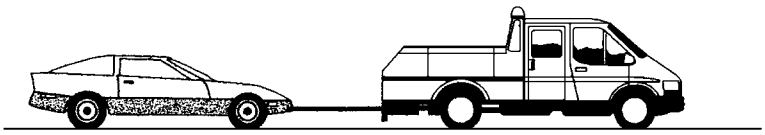


(a) By resolving forces horizontally, show that the tension is the same in each string. *(2 marks)*

(b) Find the tension in each string. *(5 marks)*

(c) If the tension in a string exceeds 40 N, the string will break. Find the mass of the heaviest sign that could be suspended as shown in the diagram. *(3 marks)*

4 A car, of mass 1200 kg, is connected by a tow rope to a truck, of mass 2800 kg. The truck tows the car in a straight line along a horizontal road. Assume that the tow rope is horizontal. A horizontal driving force of magnitude 3000 N acts on the truck. A horizontal resistance force of magnitude 800 N acts on the car. The car and truck accelerate at $0.4\,\text{m}\,\text{s}^{-2}$.



(a) Find the tension in the tow rope. *(3 marks)*

(b) Show that the magnitude of the horizontal resistance force acting on the truck is 600 N. *(4 marks)*

(c) In fact, the tow rope is **not** horizontal. Assume that the resistance forces and the driving force are unchanged.

Is the tension in the tow rope greater or less than in part (a)?

Explain why. *(2 marks)*

5 An aeroplane flies in air that is moving due east at a speed of $V\,\text{m}\,\text{s}^{-1}$. The velocity of the aeroplane relative to the air is $150\,\text{m}\,\text{s}^{-1}$ due north. The aeroplane actually travels on a bearing of 030°.

(a) Show that $V = 86.6\,\text{m}\,\text{s}^{-1}$, correct to three significant figures. *(2 marks)*

(b) Find the magnitude of the resultant velocity of the aeroplane. *(3 marks)*

Turn over for the next question

6 A box, of mass 3 kg, is placed on a slope inclined at an angle of 30° to the horizontal. The box slides down the slope. Assume that air resistance can be ignored.

(a) A simple model assumes that the slope is smooth.

(i) Draw a diagram to show the forces acting on the box. *(1 mark)*

(ii) Show that the acceleration of the box is $4.9\,\mathrm{m\,s^{-2}}$. *(2 marks)*

(b) A revised model assumes that the slope is rough. The box slides down the slope from rest, travelling 5 metres in 2 seconds.

(i) Show that the acceleration of the box is $2.5\,\mathrm{m\,s^{-2}}$. *(2 marks)*

(ii) Find the magnitude of the friction force acting on the box. *(3 marks)*

(iii) Find the coefficient of friction between the box and the slope. *(5 marks)*

(iv) In reality, air resistance affects the motion of the box. Explain how its acceleration would change if you took this into account. *(2 marks)*

7 An arrow is fired from a point A with a velocity of $25\,\mathrm{m\,s^{-1}}$, at an angle of 40° above the horizontal. The arrow hits a target at the point B which is at the same level as the point A, as shown in the diagram.

(a) State **two** assumptions that you should make in order to model the motion of the arrow. *(2 marks)*

(b) Show that the time that it takes for the arrow to travel from A to B is 3.28 seconds, correct to three significant figures. *(4 marks)*

(c) Find the distance between the points A and B. *(2 marks)*

(d) State the magnitude and direction of the velocity of the arrow when it hits the target. *(2 marks)*

(e) Find the minimum speed of the arrow during its flight. *(2 marks)*

8 A boat is initially at the origin, heading due east at $5\,\mathrm{m\,s^{-1}}$. It then experiences a constant acceleration of $(-0.2\mathbf{i} + 0.25\mathbf{j})\,\mathrm{m\,s^{-2}}$. The unit vectors **i** and **j** are directed east and north respectively.

(a) State the initial velocity of the boat as a vector. *(1 mark)*

(b) Find an expression for the velocity of the boat t seconds after it has started to accelerate. *(2 marks)*

(c) Find the value of t when the boat is travelling due north. *(3 marks)*

(d) Find the bearing of the boat from the origin when the boat is travelling due north. *(6 marks)*

END OF QUESTIONS

General Certificate of Education
January 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

MATHEMATICS **MM1B**
Unit Mechanics 1B

Friday 11 January 2008 9.00 am to 10.30 am

For this paper you must have:
- an 8-page answer book
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1B.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 A crane is used to lift a crate, of mass 70 kg, vertically upwards. As the crate is lifted, it accelerates uniformly from rest, rising 8 metres in 5 seconds.

(a) Show that the acceleration of the crate is $0.64\,\mathrm{m\,s^{-2}}$. *(2 marks)*

(b) The crate is attached to the crane by a single cable. Assume that there is no resistance to the motion of the crate.

Find the tension in the cable. *(3 marks)*

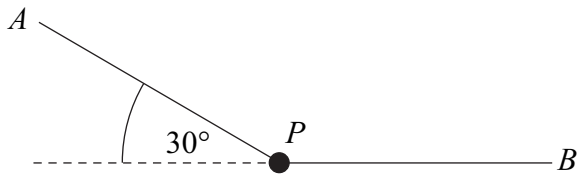
(c) Calculate the average speed of the crate during these 5 seconds. *(1 mark)*

2 The velocity of a ship, relative to the water in which it is moving, is $8\,\mathrm{m\,s^{-1}}$ due north. The water is moving due east with a speed of $U\,\mathrm{m\,s^{-1}}$. The resultant velocity of the ship has magnitude $10\,\mathrm{m\,s^{-1}}$.

(a) Find U. *(2 marks)*

(b) Find the direction of the resultant velocity of the ship. Give your answer as a bearing to the nearest degree. *(2 marks)*

3 A particle, of mass 4 kg, is suspended in equilibrium by two light strings, AP and BP. The string AP makes an angle of 30° to the horizontal and the other string, BP, is horizontal, as shown in the diagram.



(a) Draw and label a diagram to show the forces acting on the particle. *(1 mark)*

(b) Show that the tension in the string AP is 78.4 N. *(3 marks)*

(c) Find the tension in the horizontal string BP. *(2 marks)*

4 Two particles, A and B, are moving on a horizontal plane when they collide and coalesce to form a single particle. The mass of A is 5 kg and the mass of B is 15 kg. Before the collision, the velocity of A is $\begin{bmatrix} 2U \\ U \end{bmatrix}$ m s^{-1} and the velocity of B is $\begin{bmatrix} V \\ -1 \end{bmatrix}$ m s^{-1}. After the collision, the velocity of the combined particle is $\begin{bmatrix} V \\ 0 \end{bmatrix}$ m s^{-1}.

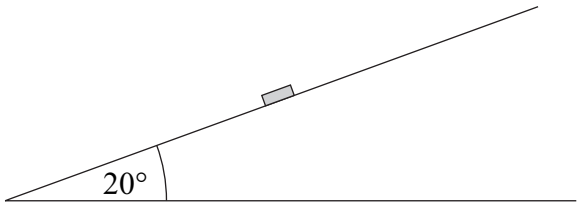
(a) Find:

(i) U; *(3 marks)*

(ii) V. *(2 marks)*

(b) Find the speed of A before the collision. *(2 marks)*

5 A puck, of mass 0.2 kg, is placed on a slope inclined at 20° above the horizontal, as shown in the diagram.



The puck is hit so that initially it moves with a velocity of 4 m s^{-1} directly up the slope.

(a) A simple model assumes that the surface of the slope is smooth.

(i) Show that the acceleration of the puck up the slope is -3.35 m s^{-2}, correct to three significant figures. *(3 marks)*

(ii) Find the distance that the puck will travel before it comes to rest. *(3 marks)*

(iii) What will happen to the puck after it comes to rest?

Explain why. *(2 marks)*

(b) A revised model assumes that the surface is rough and that the coefficient of friction between the puck and the surface is 0.5.

(i) Show that the magnitude of the friction force acting on the puck during this motion is 0.921 N, correct to three significant figures. *(3 marks)*

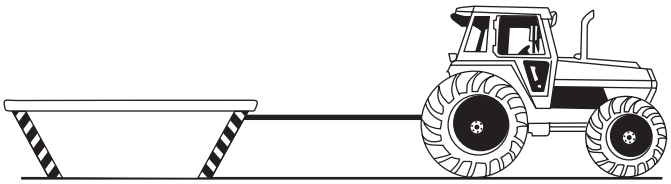
(ii) Find the acceleration of the puck up the slope. *(3 marks)*

(iii) What will happen to the puck after it comes to rest in this case?

Explain why. *(2 marks)*

Turn over ▶

6 A tractor, of mass 4000 kg, is used to pull a skip, of mass 1000 kg, over a rough horizontal surface. The tractor is connected to the skip by a rope, which remains taut and horizontal throughout the motion, as shown in the diagram.



Assume that only **two** horizontal forces act on the tractor. One is a driving force, which has magnitude P newtons and acts in the direction of motion. The other is the tension in the rope.

The coefficient of friction between the skip and the ground is 0.4.

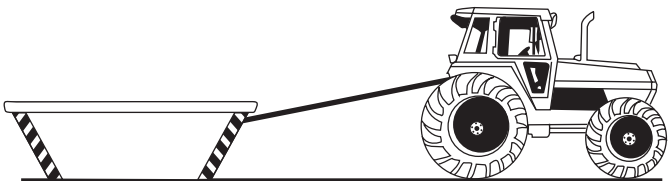
The tractor and the skip accelerate at $0.8\,\text{m}\,\text{s}^{-2}$.

(a) Show that the magnitude of the friction force acting on the skip is 3920 N. *(2 marks)*

(b) Show that $P = 7920$. *(3 marks)*

(c) Find the tension in the rope. *(3 marks)*

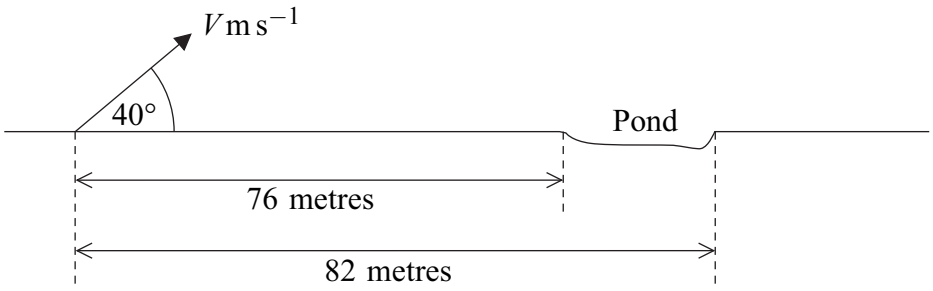
(d) Suppose that, during the motion, the rope is **not** horizontal, but inclined at a small angle to the horizontal, with the higher end of the rope attached to the tractor, as shown in the diagram.



How would the magnitude of the friction force acting on the skip differ from that found in part (a)?

Explain why. *(2 marks)*

7 A golfer hits a ball which is on horizontal ground. The ball initially moves with speed $V\,\text{m s}^{-1}$ at an angle of 40° above the horizontal. There is a pond further along the horizontal ground. The diagram below shows the initial position of the ball and the position of the pond.



(a) State **two** assumptions that you should make in order to model the motion of the ball. *(2 marks)*

(b) Show that the horizontal distance, in metres, travelled by the ball when it returns to ground level is

$$\frac{V^2 \sin 40° \cos 40°}{4.9}$$ *(6 marks)*

(c) Find the range of values of V for which the ball lands in the pond. *(4 marks)*

8 A Jet Ski is at the origin and is travelling due north at $5\,\text{m s}^{-1}$ when it begins to accelerate uniformly. After accelerating for 40 seconds, it is travelling due east at $4\,\text{m s}^{-1}$. The unit vectors **i** and **j** are directed east and north respectively.

(a) Show that the acceleration of the Jet Ski is $(0.1\,\mathbf{i} - 0.125\,\mathbf{j})\,\text{m s}^{-2}$. *(4 marks)*

(b) Find the position vector of the Jet Ski at the end of the 40 second period. *(3 marks)*

(c) The Jet Ski is travelling southeast t seconds after it leaves the origin.

(i) Find t. *(5 marks)*

(ii) Find the velocity of the Jet Ski at this time. *(2 marks)*

END OF QUESTIONS

General Certificate of Education
June 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

MATHEMATICS **MM1B**
Unit Mechanics 1B

Monday 2 June 2008 9.00 am to 10.30 am

For this paper you must have:
- an 8-page answer book
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 30 minutes

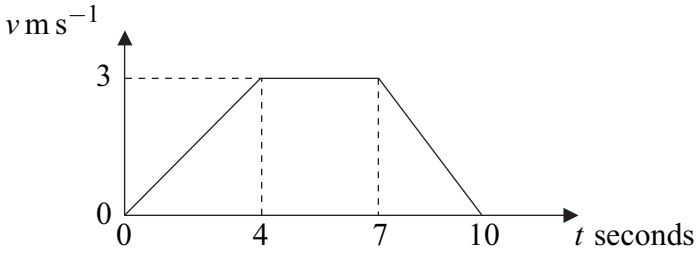
Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1B.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 The diagram shows a velocity–time graph for a lift.

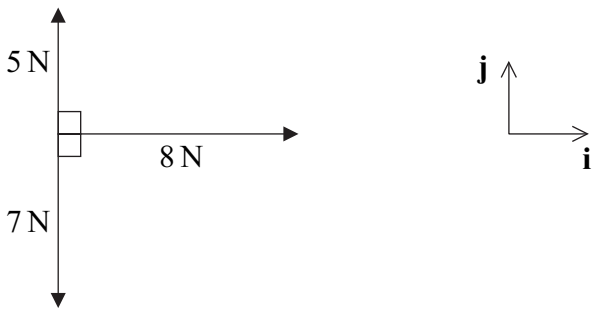


(a) Find the distance travelled by the lift. *(3 marks)*

(b) Find the acceleration of the lift during the first 4 seconds of the motion. *(1 mark)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 400 kg. Find the tension in the cable during the first 4 seconds of the motion. *(3 marks)*

2 The diagram shows three forces and the perpendicular unit vectors **i** and **j**, which all lie in the same plane.

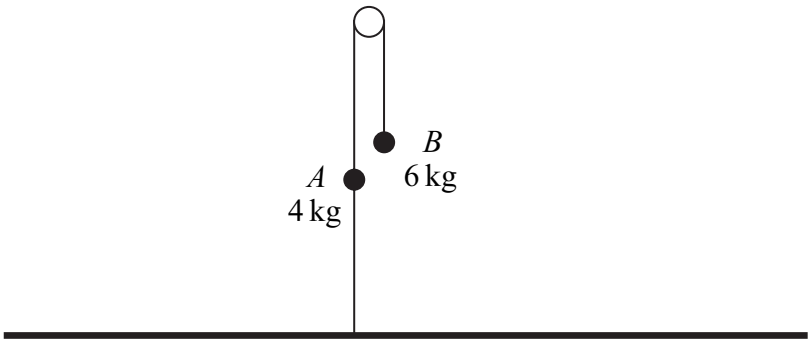


(a) Express the resultant of the three forces in terms of **i** and **j**. *(2 marks)*

(b) Find the magnitude of the resultant force. *(2 marks)*

(c) Draw a diagram to show the direction of the resultant force, and find the angle that it makes with the unit vector **i**. *(3 marks)*

3 Two particles, A and B, have masses 4 kg and 6 kg respectively. They are connected by a light inextensible string that passes over a smooth fixed peg. A second light inextensible string is attached to A. The other end of this string is attached to the ground directly below A. The system remains at rest, as shown in the diagram.



(a) (i) Write down the tension in the string connecting A and B. *(1 mark)*

(ii) Find the tension in the string connecting A to the ground. *(3 marks)*

(b) The string connecting particle A to the ground is cut. Find the acceleration of A after the string has been cut. *(5 marks)*

4 An aeroplane is travelling due north at $180\,\text{m s}^{-1}$ relative to the air. The air is moving north-west at $50\,\text{m s}^{-1}$.

(a) Find the magnitude of the resultant velocity of the aeroplane. *(4 marks)*

(b) Find the direction of the resultant velocity, giving your answer as a three-figure bearing to the nearest degree. *(4 marks)*

5 The unit vectors **i** and **j** are directed east and north respectively. A helicopter moves horizontally with a constant acceleration of $(-0.4\mathbf{i} + 0.5\mathbf{j})\,\text{m s}^{-2}$. At time $t = 0$, the helicopter is at the origin and has velocity $20\mathbf{i}\,\text{m s}^{-1}$.

(a) Write down an expression for the velocity of the helicopter at time t seconds. *(2 marks)*

(b) Find the time when the helicopter is travelling due north. *(3 marks)*

(c) Find an expression for the position vector of the helicopter at time t seconds. *(2 marks)*

(d) When $t = 100$:

(i) show that the helicopter is due north of the origin; *(3 marks)*

(ii) find the speed of the helicopter. *(3 marks)*

Turn over ▶

6 A block, of mass 5 kg, slides down a rough plane inclined at 40° to the horizontal. When modelling the motion of the block, assume that there is no air resistance acting on it.

(a) Draw and label a diagram to show the forces acting on the block. *(1 mark)*

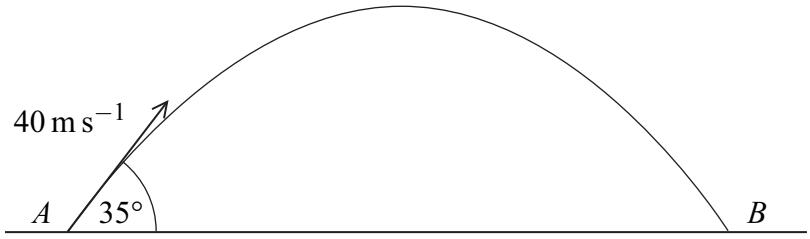
(b) Show that the magnitude of the normal reaction force acting on the block is 37.5 N, correct to three significant figures. *(2 marks)*

(c) Given that the acceleration of the block is $0.8\,\text{m s}^{-2}$, find the coefficient of friction between the block and the plane. *(6 marks)*

(d) In reality, air resistance does act on the block. State how this would change your value for the coefficient of friction and explain why. *(2 marks)*

7 A ball is hit by a bat so that, when it leaves the bat, its velocity is $40\,\text{m s}^{-1}$ at an angle of 35° above the horizontal. Assume that the ball is a particle and that its weight is the only force that acts on the ball after it has left the bat.

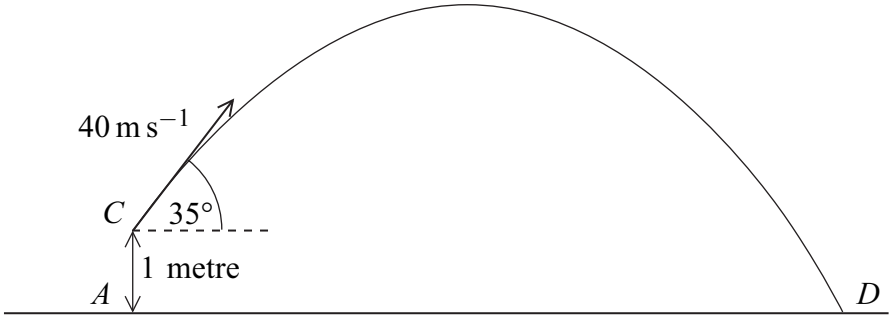
(a) A simple model assumes that the ball is hit from the point A and lands for the first time at the point B, which is at the same level as A, as shown in the diagram.



(i) Show that the time that it takes for the ball to travel from A to B is 4.68 seconds, correct to three significant figures. *(4 marks)*

(ii) Find the horizontal distance from A to B. *(2 marks)*

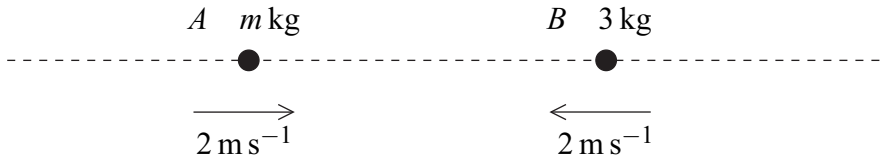
(b) A revised model assumes that the ball is hit from the point C, which is 1 metre above A. The ball lands at the point D, which is at the same level as A, as shown in the diagram.



Find the time that it takes for the ball to travel from C to D. *(6 marks)*

8 Two particles, A and B, are travelling towards each other along a straight horizontal line.

Particle A has velocity $2\,\text{m s}^{-1}$ and mass $m\,\text{kg}$.
Particle B has velocity $-2\,\text{m s}^{-1}$ and mass $3\,\text{kg}$.



The particles collide.

(a) If the particles move in opposite directions after the collision, each with speed $0.5\,\text{m s}^{-1}$, find the value of m. *(3 marks)*

(b) If the particles coalesce during the collision, forming a single particle which moves with speed $0.5\,\text{m s}^{-1}$, find the two possible values of m. *(5 marks)*

END OF QUESTIONS

General Certificate of Education
January 2009
Advanced Subsidiary Examination

MATHEMATICS MM1B
Unit Mechanics 1B

Monday 19 January 2009 1.30 pm to 3.00 pm

For this paper you must have:
- an 8-page answer book
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MM1B.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$, unless stated otherwise.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

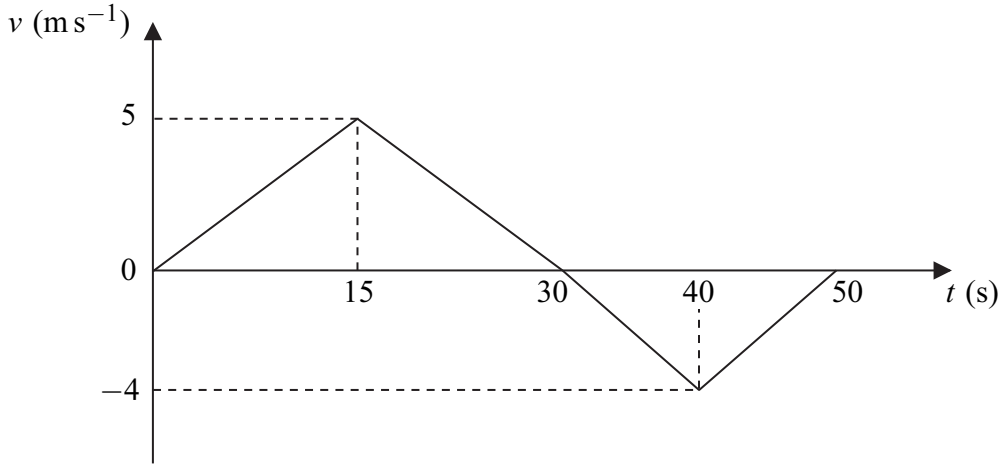
Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 Two particles, A and B, are travelling in the same direction with constant speeds along a straight line when they collide. Particle A has mass 2.5 kg and speed $12\,\text{m s}^{-1}$. Particle B has mass 1.5 kg and speed $4\,\text{m s}^{-1}$. After the collision, the two particles move together at the same speed.

Find the speed of the particles after the collision. *(3 marks)*

2 The graph shows how the velocity of a particle varies during a 50-second period as it moves forwards and then backwards on a straight line.



(a) State the times at which the velocity of the particle is zero. *(2 marks)*

(b) Show that the particle travels a distance of 75 metres during the first 30 seconds of its motion. *(2 marks)*

(c) Find the total distance travelled by the particle during the 50 seconds. *(4 marks)*

(d) Find the distance of the particle from its initial position at the end of the 50-second period. *(2 marks)*

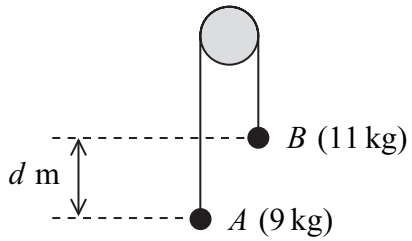
3 A box of mass 4 kg is held at rest on a plane inclined at an angle of 40° to the horizontal. The box is then released and slides down the plane.

(a) A simple model assumes that the only forces acting on the box are its weight and the normal reaction from the plane. Show that, according to this simple model, the acceleration of the box would be $6.30\,\mathrm{m\,s^{-2}}$, correct to three significant figures. *(3 marks)*

(b) In fact, the box moves down the plane with constant acceleration and travels 0.9 metres in 0.6 seconds. By using this information, find the acceleration of the box. *(3 marks)*

(c) Explain why the answer to part (b) is less than the answer to part (a). *(1 mark)*

4 Two particles, A and B, are connected by a string that passes over a fixed peg, as shown in the diagram. The mass of A is 9 kg and the mass of B is 11 kg.



The particles are released from rest in the position shown, where B is d metres higher than A. The motion of the particles is to be modelled using simple assumptions.

(a) State one assumption that should be made about the peg. *(1 mark)*

(b) State two assumptions that should be made about the string. *(2 marks)*

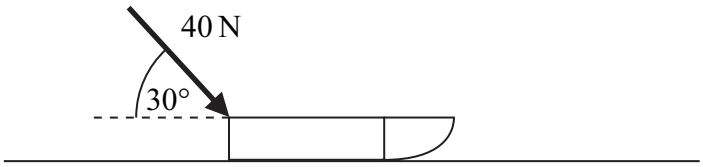
(c) By forming an equation of motion for each of the particles A and B, show that the acceleration of each particle has magnitude $0.98\,\mathrm{m\,s^{-2}}$. *(5 marks)*

(d) When the particles have been moving for 0.5 seconds, they are at the same level.

(i) Find the speed of the particles at this time. *(2 marks)*

(ii) Find d. *(4 marks)*

5 A sledge of mass 8 kg is at rest on a rough horizontal surface. A child tries to move the sledge by pushing it with a pole, as shown in the diagram, but the sledge **does not move**. The pole is at an angle of 30° to the horizontal and exerts a force of 40 newtons on the sledge.



Model the sledge as a particle.

(a) Draw a diagram to show the four forces acting on the sledge. *(1 mark)*

(b) Show that the normal reaction force between the sledge and the surface has magnitude 98.4 N. *(3 marks)*

(c) Find the magnitude of the friction force that acts on the sledge. *(2 marks)*

(d) Find the least possible value of the coefficient of friction between the sledge and the surface. *(3 marks)*

6 Two forces, $\mathbf{P} = (6\mathbf{i} - 3\mathbf{j})$ newtons and $\mathbf{Q} = (3\mathbf{i} + 15\mathbf{j})$ newtons, act on a particle. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are perpendicular.

(a) Find the resultant of $\mathbf{P}$ and $\mathbf{Q}$. *(2 marks)*

(b) Calculate the magnitude of the resultant of $\mathbf{P}$ and $\mathbf{Q}$. *(2 marks)*

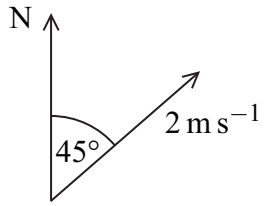
(c) When these two forces act on the particle, it has an acceleration of $(1.5\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-2}}$. Find the mass of the particle. *(2 marks)*

(d) The particle was initially at rest at the origin.

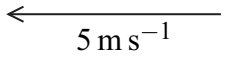
(i) Find an expression for the position vector of the particle when the forces have been applied to the particle for t seconds. *(2 marks)*

(ii) Find the distance of the particle from the origin when the forces have been applied to the particle for 2 seconds. *(2 marks)*

7 A boat is travelling in water that is moving north-east at a speed of $2\,\mathrm{m\,s^{-1}}$. The velocity of the boat relative to the water is $5\,\mathrm{m\,s^{-1}}$ due west.



Velocity of the water



Velocity of the boat relative to the water

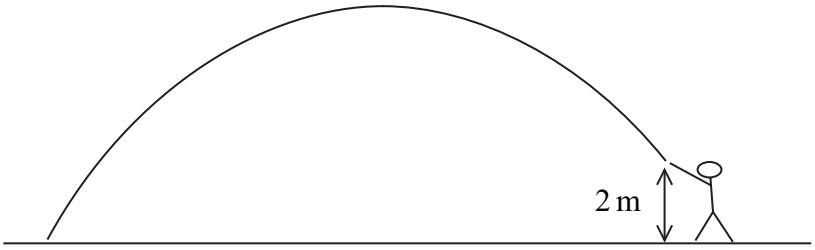
(a) Show that the magnitude of the resultant velocity of the boat is $3.85\,\mathrm{m\,s^{-1}}$, correct to three significant figures. *(4 marks)*

(b) Find the bearing on which the boat is travelling, giving your answer to the nearest degree. *(4 marks)*

8 A cricket ball is hit at ground level on a horizontal surface. It initially moves at $28\,\mathrm{m\,s^{-1}}$ at an angle of 50° above the horizontal.

(a) Find the maximum height of the ball during its flight. *(4 marks)*

(b) The ball is caught when it is at a height of 2 metres above ground level, as shown in the diagram.



Show that the time that it takes for the ball to travel from the point where it was hit to the point where it was caught is 4.28 seconds, correct to three significant figures. *(5 marks)*

(c) Find the speed of the ball when it is caught. *(5 marks)*

END OF QUESTIONS

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
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General Certificate of Education
Advanced Subsidiary Examination
June 2009

Mathematics MM1B

Unit Mechanics 1B

Specimen paper for examinations in June 2010 onwards

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the space provided. Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\ \mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions in the spaces provided.

1 Two particles, A and B, are moving on a smooth horizontal surface when they collide. During the collision, the two particles coalesce to form a single combined particle. Particle A has mass 3 kg and particle B has mass 7 kg.

Before the collision, the velocity of A is $\begin{bmatrix} 6 \\ -2 \end{bmatrix}$ m s^{-1} and the velocity of B is $\begin{bmatrix} -1 \\ 4 \end{bmatrix}$ m s^{-1}.

(a) Find the velocity of the combined particle after the collision. *(3 marks)*

(b) Find the speed of the combined particle after the collision. *(2 marks)*

QUESTION PART REFERENCE

Do not write outside the box

2 A lift is travelling upwards and accelerating uniformly. During a 5 second period, it travels 16 metres and the speed of the lift increases from $u\,\mathrm{m\,s^{-1}}$ to $4.2\,\mathrm{m\,s^{-1}}$.

(a) Find u. *(3 marks)*

(b) Find the acceleration of the lift. *(3 marks)*

QUESTION PART REFERENCE

3 A car is travelling in a straight line on a horizontal road. A driving force, of magnitude 3000 N, acts in the direction of motion and a resistance force, of magnitude 600 N, opposes the motion of the car. Assume that no other horizontal forces act on the car.

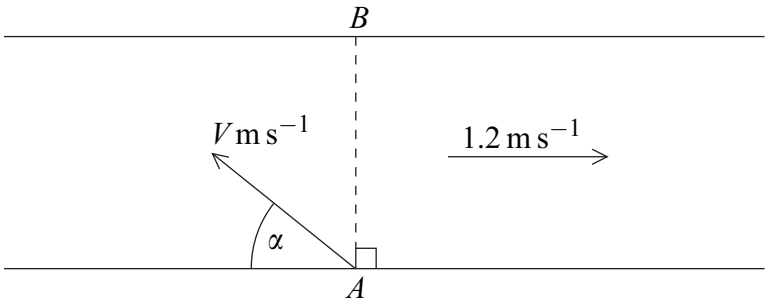
(a) Find the magnitude of the resultant force on the car. *(2 marks)*

(b) The mass of the car is 1200 kg. Find the acceleration of the car. *(2 marks)*

QUESTION PART REFERENCE

4 A river has parallel banks which are 16 metres apart. The water in the river flows at $1.2\,\text{m s}^{-1}$ parallel to the banks. A boat sets off from one bank at the point A and travels perpendicular to the bank so that it reaches the point B, which is directly opposite the point A. It takes the boat 10 seconds to cross the river.

The velocity of the boat relative to the water has magnitude $V\,\text{m s}^{-1}$ and is at an angle α to the bank, as shown in the diagram.



(a) Show that the magnitude of the resultant velocity of the boat is $1.6\,\text{m s}^{-1}$. *(1 mark)*

(b) Find V. *(3 marks)*

(c) Find α. *(2 marks)*

(d) State one modelling assumption that you needed to make about the boat. *(1 mark)*

QUESTION PART REFERENCE

5 A block, of mass 14 kg, is held at rest on a rough horizontal surface. The coefficient of friction between the block and the surface is 0.25. A light inextensible string, which passes over a fixed smooth peg, is attached to the block. The other end of the string is attached to a particle, of mass 6 kg, which is hanging at rest.

The block is released and begins to accelerate.

(a) Find the magnitude of the friction force acting on the block. *(3 marks)*

(b) By forming two equations of motion, one for the block and one for the particle, show that the magnitude of the acceleration of the block and the particle is $1.225\,\text{m}\,\text{s}^{-2}$. *(5 marks)*

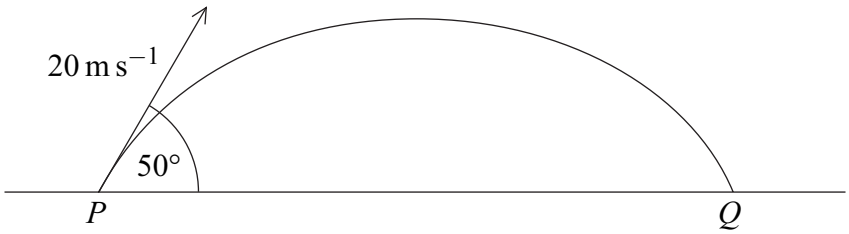
(c) Find the tension in the string. *(2 marks)*

(d) When the block is released, it is 0.8 metres from the peg. Find the speed of the block when it hits the peg. *(3 marks)*

(e) When the block reaches the peg, the string breaks and the particle falls a further 0.5 metres to the ground. Find the speed of the particle when it hits the ground. *(3 marks)*

QUESTION PART REFERENCE

6 A ball is kicked from the point P on a horizontal surface. It leaves the surface with a velocity of $20\,\text{m}\,\text{s}^{-1}$ at an angle of 50° above the horizontal and hits the surface for the first time at the point Q. Assume that the ball is a particle that moves only under the influence of gravity.



(a) Show that the time that it takes the ball to travel from P to Q is 3.13 s, correct to three significant figures. *(4 marks)*

(b) Find the distance between the points P and Q. *(2 marks)*

(c) If a heavier ball were projected from P with the same velocity, how would the distance between P and Q, calculated using the same modelling assumptions, compare with your answer to part **(b)**? Give a reason for your answer. *(2 marks)*

(d) Find the maximum height of the ball above the horizontal surface. *(3 marks)*

(e) State the magnitude and direction of the velocity of the ball as it hits the surface. *(2 marks)*

QUESTION PART REFERENCE

7 A particle moves on a smooth horizontal plane. It is initially at the point A, with position vector $(9\mathbf{i} + 7\mathbf{j})$ m, and has velocity $(-2\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. The particle moves with a constant acceleration of $(0.25\mathbf{i} + 0.3\mathbf{j})\,\mathrm{m\,s^{-2}}$ for 20 seconds until it reaches the point B. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively.

(a) Find the velocity of the particle at the point B. *(3 marks)*

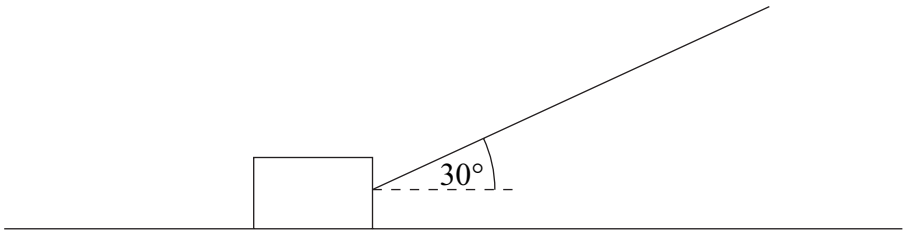
(b) Find the velocity of the particle when it is travelling due north. *(4 marks)*

(c) Find the position vector of the point B. *(3 marks)*

(d) Find the average velocity of the particle as it moves from A to B. *(2 marks)*

QUESTION PART REFERENCE

8 The diagram shows a block, of mass 20 kg, being pulled along a rough horizontal surface by a rope inclined at an angle of 30° to the horizontal.



The coefficient of friction between the block and the surface is μ. Model the block as a particle which slides on the surface.

(a) If the tension in the rope is 60 newtons, the block moves at a constant speed.

(i) Show that the magnitude of the normal reaction force acting on the block is 166 N. *(3 marks)*

(ii) Find μ. *(4 marks)*

(b) If the rope remains at the same angle and the block accelerates at $0.8\,\text{m}\,\text{s}^{-2}$, find the tension in the rope. *(5 marks)*

QUESTION PART REFERENCE

General Certificate of Education
Advanced Subsidiary Examination
January 2010

Mathematics MM1B

Unit Mechanics 1B

Friday 15 January 2010 1.30 pm to 3.00 pm

For this paper you must have:
- an 8-page answer book
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

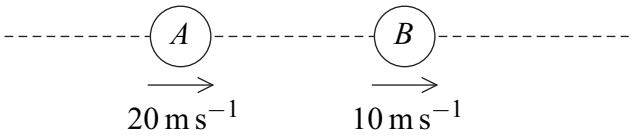
Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The **Examining Body** for this paper is AQA. The **Paper Reference** is MM1B.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 Two particles, A and B, are travelling in the same direction along a straight line on a smooth horizontal surface. Particle A has mass 3 kg and particle B has mass 7 kg. Particle A has a speed of $20\,\text{m s}^{-1}$ and particle B has a speed of $10\,\text{m s}^{-1}$, as shown in the diagram.



Particle A and particle B collide and coalesce to form a single particle. Find the speed of this single particle after the collision. *(3 marks)*

2 A sprinter accelerates from rest at a constant rate for the first 10 metres of a 100-metre race. He takes 2.5 seconds to run the first 10 metres.

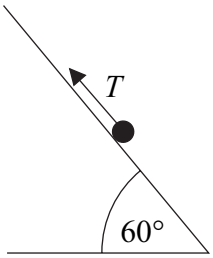
(a) Find the acceleration of the sprinter during the first 2.5 seconds of the race. *(3 marks)*

(b) Show that the speed of the sprinter at the end of the first 2.5 seconds of the race is $8\,\text{m s}^{-1}$. *(2 marks)*

(c) The sprinter completes the 100-metre race, travelling the remaining 90 metres at a constant speed of $8\,\text{m s}^{-1}$. Find the total time taken for the sprinter to travel the 100 metres. *(3 marks)*

(d) Calculate the average speed of the sprinter during the 100-metre race. *(2 marks)*

3 A particle of mass 3 kg is on a smooth slope inclined at 60° to the horizontal. The particle is held at rest by a force of T newtons parallel to the slope, as shown in the diagram.



(a) Draw a diagram to show all the forces acting on the particle. *(1 mark)*

(b) Show that the magnitude of the normal reaction acting on the particle is 14.7 newtons. *(2 marks)*

(c) Find T. *(2 marks)*

4 A ball is released from rest at a height of 15 metres above ground level.

(a) Find the speed of the ball when it hits the ground, assuming that no air resistance acts on the ball. *(3 marks)*

(b) In fact, air resistance does act on the ball. Assume that the air resistance force has a constant magnitude of 0.9 newtons. The ball has a mass of 0.5 kg.

(i) Draw a diagram to show the forces acting on the ball, including the magnitudes of the forces acting. *(1 mark)*

(ii) Show that the acceleration of the ball is $8\,\mathrm{m\,s^{-2}}$. *(3 marks)*

(iii) Find the speed at which the ball hits the ground. *(2 marks)*

(iv) Explain why the assumption that the air resistance force is constant may not be valid. *(1 mark)*

5 The constant forces $\mathbf{F}_1 = (8\mathbf{i} + 12\mathbf{j})$ newtons and $\mathbf{F}_2 = (4\mathbf{i} - 4\mathbf{j})$ newtons act on a particle. No other forces act on the particle.

(a) Find the resultant force acting on the particle. *(2 marks)*

(b) Given that the mass of the particle is 4 kg, show that the acceleration of the particle is $(3\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-2}}$. *(2 marks)*

(c) At time t seconds, the velocity of the particle is $\mathbf{v}\,\mathrm{m\,s^{-1}}$.

(i) When $t = 20$, $\mathbf{v} = 40\mathbf{i} + 32\mathbf{j}$.

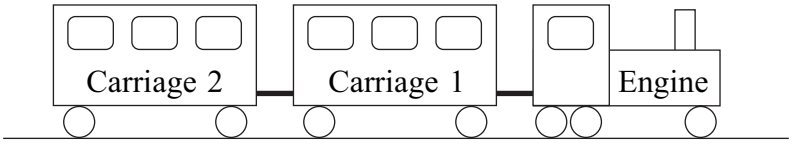
Show that $\mathbf{v} = -20\mathbf{i} - 8\mathbf{j}$ when $t = 0$. *(3 marks)*

(ii) Write down an expression for $\mathbf{v}$ at time t. *(1 mark)*

(iii) Find the times when the speed of the particle is $8\,\mathrm{m\,s^{-1}}$. *(6 marks)*

Turn over for the next question

6 A small train at an amusement park consists of an engine and two carriages connected to each other by light horizontal rods, as shown in the diagram.



The engine has mass 2000 kg and each carriage has mass 500 kg.

The train moves along a straight horizontal track. A resistance force of magnitude 400 newtons acts on the engine, and resistance forces of magnitude 300 newtons act on each carriage. The train is accelerating at $0.5\,\text{m}\,\text{s}^{-2}$.

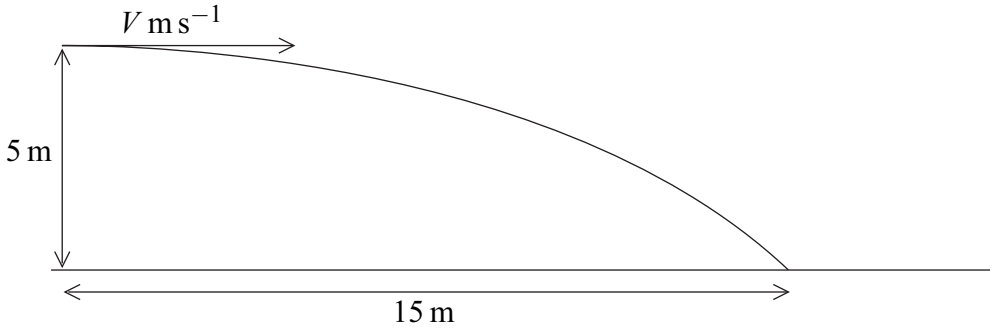
(a) Draw a diagram to show the **horizontal** forces acting on Carriage 2. *(1 mark)*

(b) Show that the magnitude of the force that the rod exerts on Carriage 2 is 550 newtons. *(2 marks)*

(c) Find the magnitude of the force that the rod attached to the engine exerts on Carriage 1. *(3 marks)*

(d) A forward driving force of magnitude P newtons acts on the engine. Find P. *(3 marks)*

7 A ball is projected horizontally with speed $V\,\text{m}\,\text{s}^{-1}$ at a height of 5 metres above horizontal ground. When the ball has travelled a horizontal distance of 15 metres, it hits the ground.



(a) Show that the time it takes for the ball to travel to the point where it hits the ground is 1.01 seconds, correct to three significant figures. *(3 marks)*

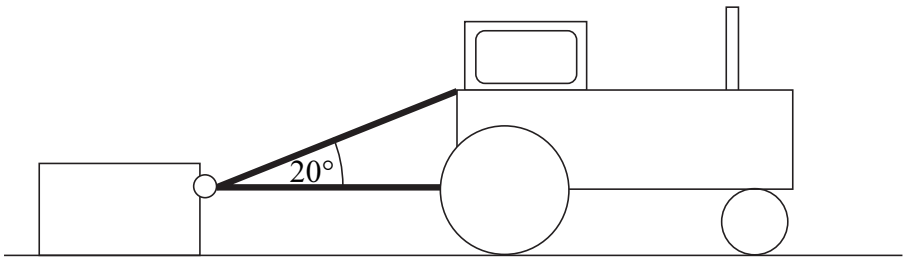
(b) Find V. *(2 marks)*

(c) Find the speed of the ball when it hits the ground. *(4 marks)*

(d) Find the angle between the velocity of the ball and the horizontal when the ball hits the ground. Give your answer to the nearest degree. *(3 marks)*

(e) State two assumptions that you have made about the ball while it is moving. *(2 marks)*

8 A crate, of mass 200 kg, is initially at rest on a rough horizontal surface. A smooth ring is attached to the crate. A light inextensible rope is passed through the ring, and each end of the rope is attached to a tractor. The lower part of the rope is horizontal and the upper part is at an angle of 20° to the horizontal, as shown in the diagram.



When the tractor moves forward, the crate accelerates at $0.3\,\mathrm{m\,s^{-2}}$. The coefficient of friction between the crate and the surface is 0.4.

Assume that the tension, T newtons, is the same in both parts of the rope.

(a) Draw and label a diagram to show the forces acting on the crate. *(2 marks)*

(b) Express the normal reaction between the surface and the crate in terms of T. *(3 marks)*

(c) Find T. *(5 marks)*

END OF QUESTIONS

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
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Question	Mark
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General Certificate of Education
Advanced Subsidiary Examination
June 2010

Mathematics MM1B

Unit Mechanics 1B

Wednesday 9 June 2010 1.30 pm to 3.00 pm

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

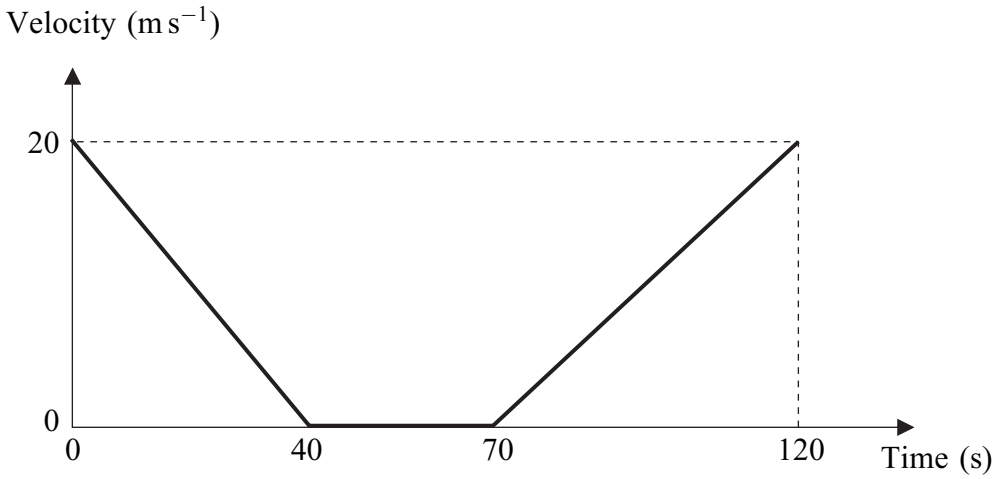
Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the spaces provided. Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions in the spaces provided.

1 A bus slows down as it approaches a bus stop. It stops at the bus stop and remains at rest for a short time as the passengers get on. It then accelerates away from the bus stop. The graph shows how the velocity of the bus varies.



Assume that the bus travels in a straight line during the motion described by the graph.

(a) State the length of time for which the bus is at rest. *(1 mark)*

(b) Find the distance travelled by the bus in the first 40 seconds. *(2 marks)*

(c) Find the total distance travelled by the bus in the 120-second period. *(2 marks)*

(d) Find the average speed of the bus in the 120-second period. *(2 marks)*

(e) If the bus had not stopped but had travelled at a constant 20 m s^{-1} for the 120-second period, how much further would it have travelled? *(2 marks)*

QUESTION PART REFERENCE

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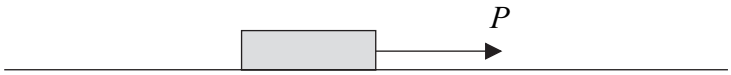
2 A block, of mass 10 kg, is at rest on a rough horizontal surface, when a horizontal force, of magnitude P newtons, is applied to the block, as shown in the diagram.



The coefficient of friction between the block and the surface is 0.5.

(a) Draw and label a diagram to show all the forces acting on the block. *(1 mark)*

(b) (i) Calculate the magnitude of the normal reaction force acting on the block. *(1 mark)*

(ii) Find the maximum possible magnitude of the friction force between the block and the surface. *(1 mark)*

(iii) Given that $P = 30$, state the magnitude of the friction force acting on the block. *(1 mark)*

(c) Given that $P = 80$, find the acceleration of the block. *(3 marks)*

QUESTION PART REFERENCE

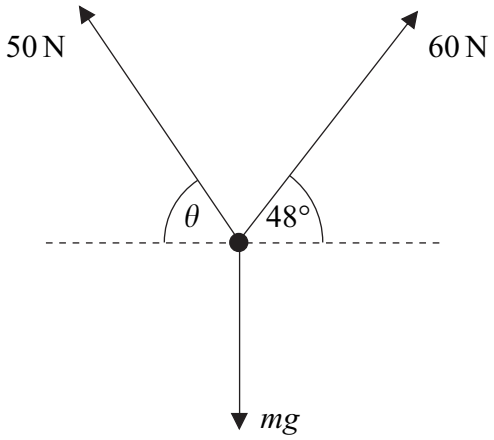
3 Two particles, A and B, are moving on a smooth horizontal plane when they collide. The mass of A is 6 kg and the mass of B is m kg. Before the collision, the velocity of A is $\begin{bmatrix} 2 \\ 4 \end{bmatrix}$ m s^{-1} and the velocity of B is $\begin{bmatrix} 3 \\ -2 \end{bmatrix}$ m s^{-1}. After the collision, the velocity of A is $\begin{bmatrix} 1 \\ 3 \end{bmatrix}$ m s^{-1} and the velocity of B is $\begin{bmatrix} 7 \\ b \end{bmatrix}$ m s^{-1}.

(a) Find m. *(4 marks)*

(b) Find b. *(2 marks)*

QUESTION PART REFERENCE

4 A particle, of mass m kg, remains in equilibrium under the action of three forces, which act in a vertical plane, as shown in the diagram. The force with magnitude 60 N acts at 48° above the horizontal and the force with magnitude 50 N acts at an angle θ above the horizontal.



(a) By resolving horizontally, find θ. *(4 marks)*

(b) Find m. *(3 marks)*

QUESTION PART REFERENCE

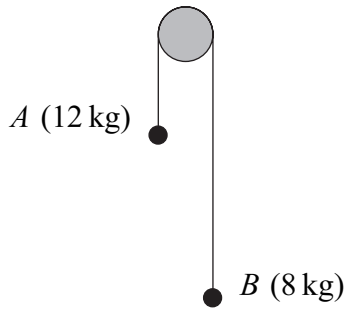
5 An aeroplane is travelling along a straight line between two points, A and B, which are at the same height. The air is moving due east at a speed of $30\,\text{m}\,\text{s}^{-1}$. Relative to the air, the aeroplane travels due north at a speed of $100\,\text{m}\,\text{s}^{-1}$.

(a) Find the magnitude of the resultant velocity of the aeroplane. *(3 marks)*

(b) Find the bearing on which the aeroplane is travelling, giving your answer to the nearest degree. *(2 marks)*

QUESTION PART REFERENCE

6 Two particles, A and B, have masses 12 kg and 8 kg respectively. They are connected by a light inextensible string that passes over a smooth fixed peg, as shown in the diagram.



The particles are released from rest and move vertically. Assume that there is no air resistance.

(a) By forming two equations of motion, show that the magnitude of the acceleration of each particle is $1.96\,\text{m s}^{-2}$. *(5 marks)*

(b) Find the tension in the string. *(2 marks)*

(c) After the particles have been moving for 2 seconds, both particles are at a height of 4 metres above a horizontal surface. When the particles are in this position, the string breaks.

(i) Find the speed of particle A when the string breaks. *(2 marks)*

(ii) Find the speed of particle A when it hits the surface. *(3 marks)*

(iii) Find the time that it takes for particle B to reach the surface after the string breaks. Assume that particle B does not hit the peg. *(5 marks)*

QUESTION PART REFERENCE

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7 A particle, of mass 10 kg, moves on a smooth horizontal surface. A single horizontal force, $(9\mathbf{i} + 12\mathbf{j})$ newtons, acts on the particle.

The unit vectors **i** and **j** are directed east and north respectively.

(a) Find the acceleration of the particle. *(2 marks)*

(b) At time t seconds, the velocity of the particle is $\mathbf{v}\,\mathrm{m\,s^{-1}}$. When $t = 0$, the velocity of the particle is $(2.2\mathbf{i} + \mathbf{j})\,\mathrm{m\,s^{-1}}$ and the particle is at the origin.

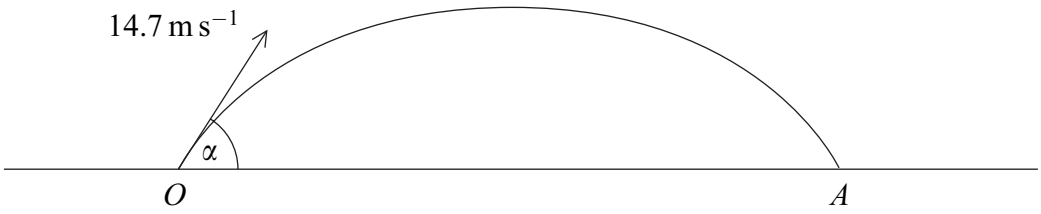
(i) Find the distance between the particle and the origin when $t = 5$. *(4 marks)*

(ii) Express **v** in terms of t. *(2 marks)*

(iii) Find t when the particle is travelling north-east. *(3 marks)*

QUESTION PART REFERENCE

8 A ball is struck so that it leaves a horizontal surface travelling at $14.7\,\mathrm{m\,s^{-1}}$ at an angle α above the horizontal. The path of the ball is shown in the diagram.



(a) Show that the ball takes $\frac{3\sin\alpha}{2}$ seconds to reach its maximum height. *(3 marks)*

(b) The ball reaches a maximum height of 7 metres.

(i) Find α. *(5 marks)*

(ii) Find the range, OA. *(3 marks)*

(c) State two assumptions that you needed to make in order to answer the earlier parts of this question. *(2 marks)*

QUESTION PART REFERENCE

Centre Number						Candidate Number				
Surname										
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Candidate Signature										

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General Certificate of Education
Advanced Subsidiary Examination
January 2011

Mathematics MM1B

Unit Mechanics 1B

Wednesday 19 January 2011 1.30 pm to 3.00 pm

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the spaces provided. Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions in the spaces provided.

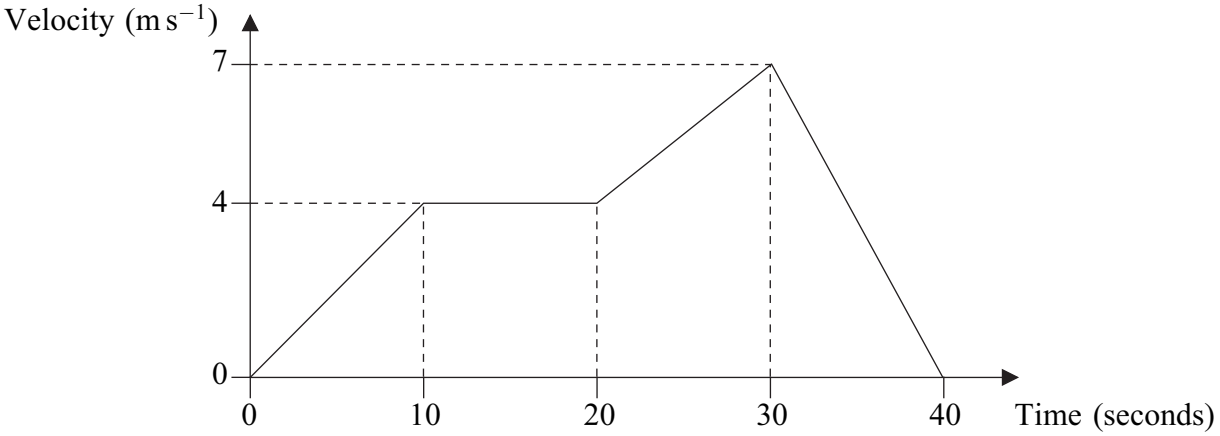
1 A trolley, of mass 5 kg, is moving in a straight line on a smooth horizontal surface. It has a velocity of $6\,\mathrm{m\,s^{-1}}$ when it collides with a stationary trolley, of mass m kg. Immediately after the collision, the trolleys move together with velocity $2.4\,\mathrm{m\,s^{-1}}$.

Find m. *(3 marks)*

QUESTION PART REFERENCE

Do not write outside the box

2 The graph shows how the velocity of a train varies as it moves along a straight railway line.



(a) Find the total distance travelled by the train. *(4 marks)*

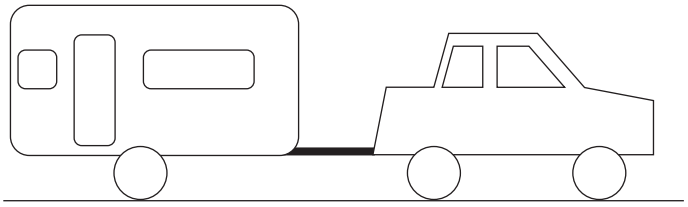
(b) Find the average speed of the train. *(2 marks)*

(c) Find the acceleration of the train during the first 10 seconds of its motion. *(2 marks)*

(d) The mass of the train is 200 tonnes. Find the magnitude of the resultant force acting on the train during the first 10 seconds of its motion. *(2 marks)*

QUESTION PART REFERENCE

3 A car, of mass 1200 kg, tows a caravan, of mass 1000 kg, along a straight horizontal road. The caravan is attached to the car by a horizontal tow bar, as shown in the diagram.



Assume that a constant resistance force of magnitude 200 newtons acts on the car and a constant resistance force of magnitude 300 newtons acts on the caravan. A constant driving force of magnitude P newtons acts on the car in the direction of motion. The car and caravan accelerate at $0.8\,\text{m s}^{-2}$.

(a) (i) Find P. *(3 marks)*

(ii) Find the magnitude of the force in the tow bar that connects the car to the caravan. *(3 marks)*

(b) (i) Find the time that it takes for the speed of the car and caravan to increase from $7\,\text{m s}^{-1}$ to $15\,\text{m s}^{-1}$. *(3 marks)*

(ii) Find the distance that they travel in this time. *(3 marks)*

(c) Explain why the assumption that the resistance forces are constant is unrealistic. *(1 mark)*

QUESTION PART REFERENCE

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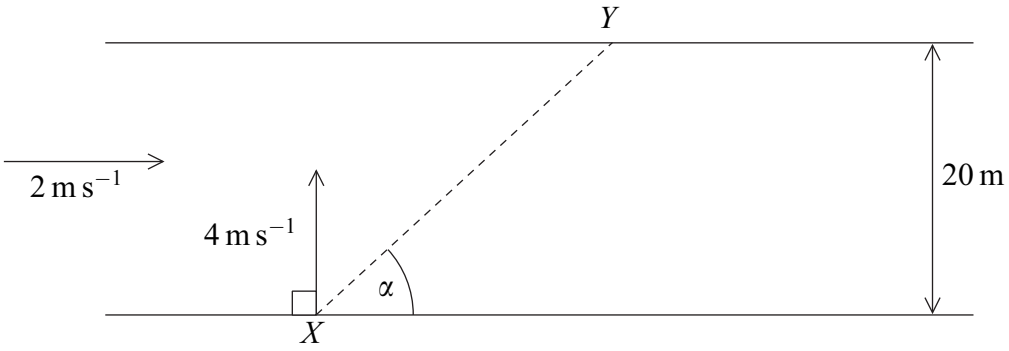
4 A canoe is paddled across a river which has a width of 20 metres. The canoe moves from the point X on one bank of the river to the point Y on the other bank, so that its path is a straight line at an angle α to the banks. The velocity of the canoe relative to the water is $4\,\text{m s}^{-1}$ perpendicular to the banks. The water flows at $2\,\text{m s}^{-1}$ parallel to the banks.



Model the canoe as a particle.

(a) Find the magnitude of the resultant velocity of the canoe. *(2 marks)*

(b) Find the angle α. *(2 marks)*

(c) Find the time that it takes for the canoe to travel from X to Y. *(2 marks)*

QUESTION PART REFERENCE

5 A particle moves with constant acceleration $(-0.4\mathbf{i} + 0.2\mathbf{j})\,\mathrm{m\,s^{-2}}$. Initially, it has velocity $(4\mathbf{i} + 0.5\mathbf{j})\,\mathrm{m\,s^{-1}}$. The unit vectors **i** and **j** are directed east and north respectively.

(a) Find an expression for the velocity of the particle at time t seconds. *(2 marks)*

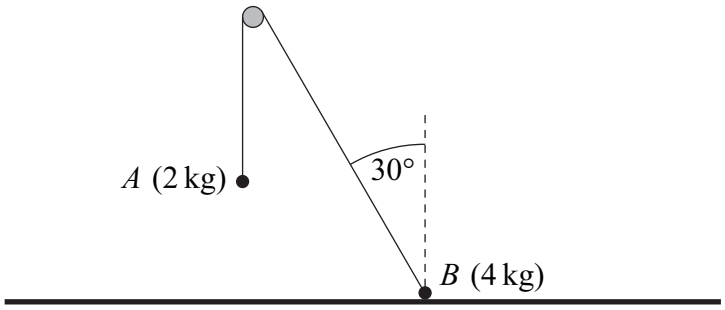
(b) (i) Find the velocity of the particle when $t = 22.5$. *(2 marks)*

(ii) State the direction in which the particle is travelling at this time. *(1 mark)*

(c) Find the time when the speed of the particle is $5\,\mathrm{m\,s^{-1}}$. *(6 marks)*

QUESTION PART REFERENCE

6 Two particles, A and B, are connected by a light inextensible string which passes over a smooth peg. Particle A has mass 2 kg and particle B has mass 4 kg. Particle A hangs freely with the string vertical. Particle B is at rest in equilibrium on a rough horizontal surface with the string at an angle of 30° to the vertical. The particles, peg and string are shown in the diagram.



(a) By considering particle A, find the tension in the string. *(2 marks)*

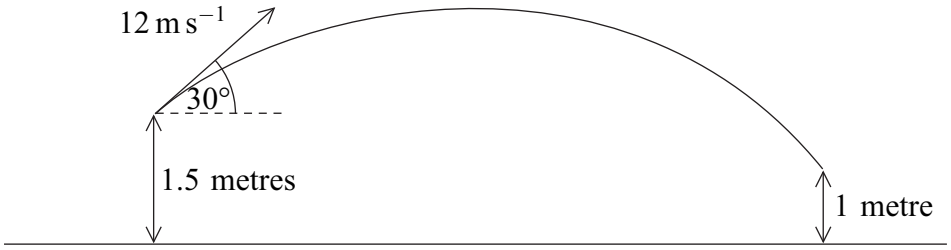
(b) Draw a diagram to show the forces acting on particle B. *(2 marks)*

(c) Show that the magnitude of the normal reaction force acting on particle B is 22.2 newtons, correct to three significant figures. *(3 marks)*

(d) Find the least possible value of the coefficient of friction between particle B and the surface. *(4 marks)*

QUESTION PART REFERENCE

7 An arrow is fired from a point at a height of 1.5 metres above horizontal ground. It has an initial velocity of $12\,\text{m}\,\text{s}^{-1}$ at an angle of 30° above the horizontal. The arrow hits a target at a height of 1 metre above horizontal ground. The path of the arrow is shown in the diagram.



Model the arrow as a particle.

(a) Show that the time taken for the arrow to travel to the target is 1.30 seconds, correct to three significant figures. *(5 marks)*

(b) Find the horizontal distance between the point where the arrow is fired and the target. *(2 marks)*

(c) Find the speed of the arrow when it hits the target. *(4 marks)*

(d) Find the angle between the velocity of the arrow and the horizontal when the arrow hits the target. *(2 marks)*

(e) State one assumption that you have made about the forces acting on the arrow. *(1 mark)*

QUESTION PART REFERENCE

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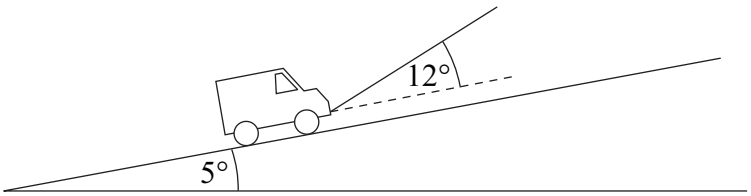
8 A van, of mass 2000 kg, is towed up a slope inclined at 5° to the horizontal. The tow rope is at an angle of 12° to the slope. The motion of the van is opposed by a resistance force of magnitude 500 newtons. The van is accelerating up the slope at $0.6\,\mathrm{m\,s^{-2}}$.



Model the van as a particle.

(a) Draw a diagram to show the forces acting on the van. *(2 marks)*

(b) Show that the tension in the tow rope is 3480 newtons, correct to three significant figures. *(5 marks)*

QUESTION PART REFERENCE

General Certificate of Education
Advanced Subsidiary Examination
June 2011

Mathematics MM1B

Unit Mechanics 1B

Thursday 26 May 2011 9.00 am to 10.30 am

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
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1 A crane is used to lift a load, using a single vertical cable which is attached to the load. The load accelerates uniformly from rest. When it has risen 0.9 metres, its speed is $0.6\,\text{m}\,\text{s}^{-1}$.

(a) (i) Show that the acceleration of the load is $0.2\,\text{m}\,\text{s}^{-2}$. *(3 marks)*

(ii) Find the time taken for the load to rise 0.9 metres. *(2 marks)*

(b) Given that the mass of the load is 800 kg, find the tension in the cable while the load is accelerating. *(3 marks)*

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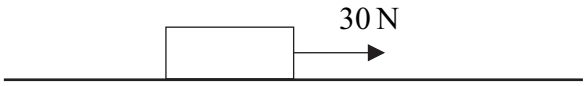
2 A wooden block, of mass 4 kg, is placed on a rough horizontal surface. The coefficient of friction between the block and the surface is 0.3 . A horizontal force, of magnitude 30 newtons, acts on the block and causes it to accelerate.



(a) Draw a diagram to show all the forces acting on the block. *(1 mark)*

(b) Calculate the magnitude of the normal reaction force acting on the block. *(1 mark)*

(c) Find the magnitude of the friction force acting on the block. *(2 marks)*

(d) Find the acceleration of the block. *(3 marks)*

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3 A pair of cameras records the time that it takes a car on a motorway to travel a distance of 2000 metres. A car passes the first camera whilst travelling at $32\,\text{m}\,\text{s}^{-1}$. The car continues at this speed for 12.5 seconds and then decelerates uniformly until it passes the second camera when its speed has decreased to $18\,\text{m}\,\text{s}^{-1}$.

(a) Calculate the distance travelled by the car in the first 12.5 seconds. *(1 mark)*

(b) Find the time for which the car is decelerating. *(3 marks)*

(c) Sketch a speed–time graph for the car on this 2000-metre stretch of motorway. *(3 marks)*

(d) Find the average speed of the car on this 2000-metre stretch of motorway. *(2 marks)*

4 Two particles, A and B, are moving on a smooth horizontal surface when they collide. The mass of A is 6 kg and the mass of B is m kg. Before the collision, the velocity of A is $(5\mathbf{i} + 18\mathbf{j})\,\mathrm{m\,s^{-1}}$ and the velocity of B is $(2\mathbf{i} - 5\mathbf{j})\,\mathrm{m\,s^{-1}}$. After the collision, the velocity of A is $8\mathbf{i}\,\mathrm{m\,s^{-1}}$ and the velocity of B is $V\mathbf{j}\,\mathrm{m\,s^{-1}}$.

(a) Find m. *(3 marks)*

(b) Find V. *(3 marks)*

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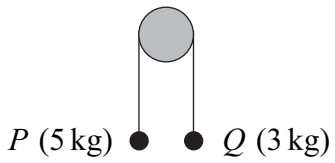
5 Two particles, P and Q, are connected by a string that passes over a fixed smooth peg, as shown in the diagram. The mass of P is 5 kg and the mass of Q is 3 kg.



The particles are released from rest in the position shown.

(a) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is $2.45\,\mathrm{m\,s^{-2}}$. *(5 marks)*

(b) Find the tension in the string. *(2 marks)*

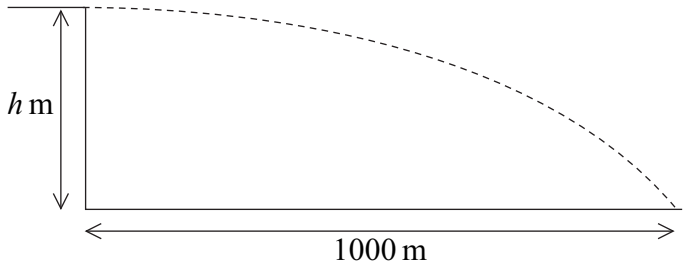
(c) State **two** modelling assumptions that you have made about the string. *(2 marks)*

(d) Particle P hits the floor when it has moved 0.196 metres and Q has not reached the peg.

(i) Find the time that it takes P to reach the floor. *(3 marks)*

(ii) Find the speed of P when it hits the floor. *(2 marks)*

6 A bullet is fired horizontally from the top of a vertical cliff, at a height of h metres above the sea. It hits the sea 4 seconds after being fired, at a distance of 1000 metres from the base of the cliff, as shown in the diagram.



(a) Find the initial speed of the bullet. *(2 marks)*

(b) Find h. *(2 marks)*

(c) Find the speed of the bullet when it hits the sea. *(4 marks)*

(d) Find the angle between the velocity of the bullet and the horizontal when it hits the sea. *(3 marks)*

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7 A helicopter is initially hovering above a lighthouse. It then sets off so that its acceleration is $(0.5\mathbf{i} + 0.375\mathbf{j})\,\mathrm{m\,s^{-2}}$. The helicopter does not change its height above sea level as it moves. The unit vectors **i** and **j** are directed east and north respectively.

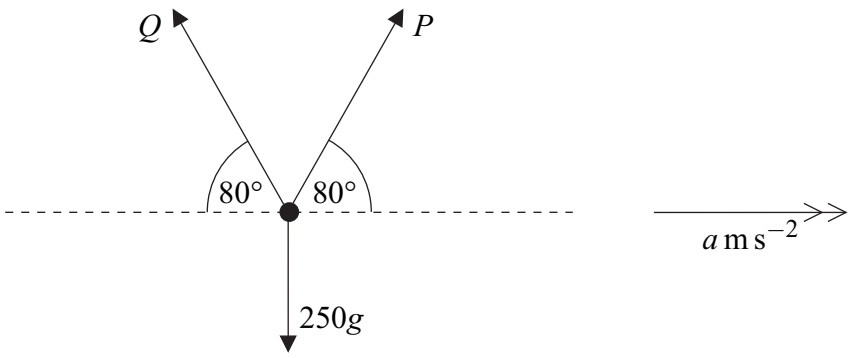
(a) Find the speed of the helicopter 20 seconds after it leaves its position above the lighthouse. *(4 marks)*

(b) Find the bearing on which the helicopter is travelling, giving your answer to the nearest degree. *(3 marks)*

(c) The helicopter stops accelerating when it is 500 metres from its initial position.

Find the time that it takes for the helicopter to travel from its initial position to the point where it stops accelerating. *(5 marks)*

8 Three forces act in a vertical plane on an object of mass 250 kg, as shown in the diagram.



The two forces P newtons and Q newtons each act at 80° to the horizontal. The object accelerates horizontally at $a\,\text{m s}^{-2}$ under the action of these forces.

(a) Show that

$$P = 125\left(\frac{a}{\cos 80°} + \frac{g}{\sin 80°}\right)$$ *(5 marks)*

(b) Find the value of a for which Q is zero. *(3 marks)*

END OF QUESTIONS

General Certificate of Education
Advanced Subsidiary Examination
January 2012

Mathematics MM1B

Unit Mechanics 1B

Friday 20 January 2012 1.30 pm to 3.00 pm

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Time allowed
- 1 hour 30 minutes

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Advice
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1 Two particles, A of mass 7 kg and B of mass 3 kg, are moving on a smooth horizontal plane when they collide. Just before the collision, the velocity of A is $(3\mathbf{i} + 8\mathbf{j})\,\text{m s}^{-1}$ and the velocity of B is $(6\mathbf{i} - 5\mathbf{j})\,\text{m s}^{-1}$. During the collision, the particles coalesce to form a single combined particle.

Find the velocity of the single combined particle after the collision. *(3 marks)*

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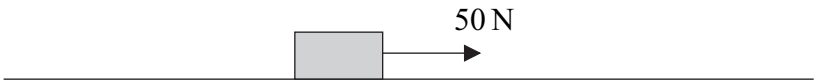
2 A block, of mass 4 kg, is made to move in a straight line on a rough horizontal surface by a horizontal force of 50 newtons, as shown in the diagram.



Assume that there is no air resistance acting on the block.

(a) Draw a diagram to show all the forces acting on the block. *(1 mark)*

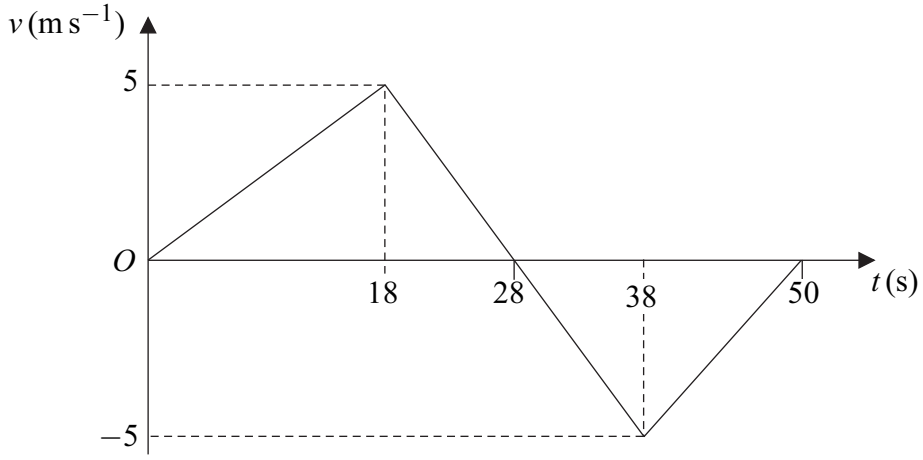
(b) Find the magnitude of the normal reaction force acting on the block. *(1 mark)*

(c) The acceleration of the block is $3\,\text{m s}^{-2}$. Find the magnitude of the friction force acting on the block. *(3 marks)*

(d) Find the coefficient of friction between the block and the surface. *(2 marks)*

(e) Explain how and why your answer to part **(d)** would change if you assumed that air resistance did act on the block. *(2 marks)*

3 The diagram shows a velocity–time graph for a train as it moves on a straight horizontal track for 50 seconds.



(a) Find the distance that the train moves in the first 28 seconds. *(2 marks)*

(b) Calculate the total distance moved by the train during the 50 seconds. *(3 marks)*

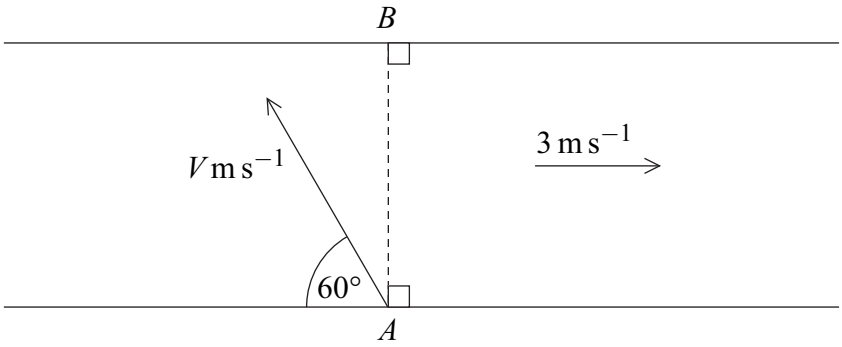
(c) Hence calculate the average speed of the train. *(2 marks)*

(d) Find the displacement of the train from its initial position when it has been moving for 50 seconds. *(1 mark)*

(e) Hence calculate the average velocity of the train. *(2 marks)*

(f) Find the acceleration of the train in the first 18 seconds of its motion. *(1 mark)*

4 A small ferry is used to cross a river which has straight parallel banks that are 200 metres apart. The water in the river moves at a constant speed of $3\,\text{m}\,\text{s}^{-1}$. The ferry travels from a point A on one bank to a point B directly opposite A on the other bank. The velocity of the ferry relative to the water is $V\,\text{m}\,\text{s}^{-1}$ at an angle of 60° to the upstream bank, as shown in the diagram.



(a) Find V. *(3 marks)*

(b) Find the time that it takes for the ferry to cross the river, giving your answer to the nearest second. *(3 marks)*

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5 A car, of mass 1200 kg, tows a caravan, of mass 1000 kg, along a straight horizontal road. The caravan is attached to the car by a horizontal towbar. A resistance force of magnitude R newtons acts on the car and a resistance force of magnitude $2R$ newtons acts on the caravan. The car and caravan accelerate at a constant $1.6\,\text{m}\,\text{s}^{-2}$ when a driving force of magnitude 4720 newtons acts on the car.

(a) Find R. *(4 marks)*

(b) Find the tension in the towbar. *(3 marks)*

6 A cyclist freewheels, with a constant acceleration, in a straight line down a slope. As the cyclist moves 50 metres, his speed increases from $4\,\mathrm{m\,s^{-1}}$ to $10\,\mathrm{m\,s^{-1}}$.

(a) (i) Find the acceleration of the cyclist. *(3 marks)*

(ii) Find the time that it takes the cyclist to travel this distance. *(3 marks)*

(b) The cyclist has a mass of 70 kg. Calculate the magnitude of the resultant force acting on the cyclist. *(2 marks)*

(c) The slope is inclined at an angle α to the horizontal.

(i) Find α if it is assumed that there is no resistance force acting on the cyclist. *(3 marks)*

(ii) Find α if it is assumed that there is a constant resistance force of magnitude 30 newtons acting on the cyclist. *(3 marks)*

(d) Make a criticism of the assumption described in part **(c)(ii)**. *(1 mark)*

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7 A helicopter is initially at rest on the ground at the origin when it begins to accelerate in a vertical plane. Its acceleration is $(4.2\mathbf{i} + 2.5\mathbf{j})\,\mathrm{m\,s^{-2}}$ for the first 20 seconds of its motion. The unit vectors **i** and **j** are horizontal and vertical respectively.

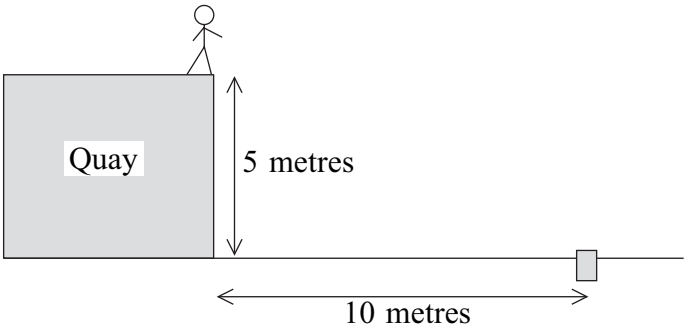
Assume that the helicopter moves over horizontal ground.

(a) Find the height of the helicopter above the ground at the end of the 20 seconds. *(3 marks)*

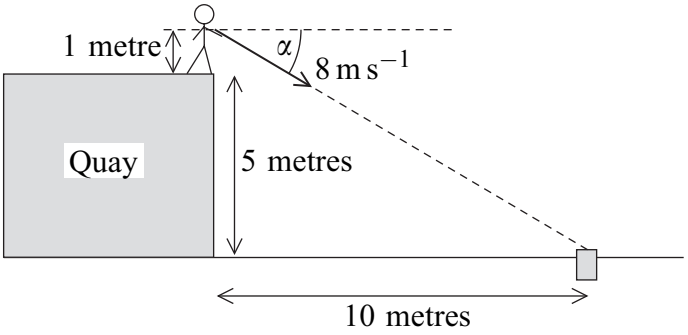
(b) Find the velocity of the helicopter at the end of the 20 seconds. *(2 marks)*

(c) Find the speed of the helicopter when it is at a height of 180 metres above the ground. *(7 marks)*

8 A girl stands at the edge of a quay and sees a tin can floating in the water. The water level is 5 metres below the top of the quay and the can is at a horizontal distance of 10 metres from the quay, as shown in the diagram.



The girl decides to throw a stone at the can. She throws the stone from a height of 1 metre above the top of the quay. The initial velocity of the stone is $8\,\mathrm{m\,s^{-1}}$ at an angle α below the horizontal, so that the initial velocity of the stone is directed at the can, as shown in the diagram.



Assume that the stone is a particle and that it experiences no air resistance as it moves.

(a) Find α. *(2 marks)*

(b) Find the time that it takes for the stone to reach the level of the water. *(6 marks)*

(c) Find the distance between the stone and the can when the stone hits the water. *(4 marks)*

General Certificate of Education
Advanced Subsidiary Examination
June 2012

Mathematics MM1B

Unit Mechanics 1B

Thursday 24 May 2012 9.00 am to 10.30 am

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1 As a boat moves, it travels at $5\,\text{m s}^{-1}$ due north, relative to the water. The water is moving due west at $2\,\text{m s}^{-1}$.

(a) Find the magnitude of the resultant velocity of the boat. *(2 marks)*

(b) Find the bearing of the resultant velocity of the boat. *(3 marks)*

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2 Two toy trains, A and B, are moving in the same direction on a straight horizontal track when they collide. As they collide, the speed of A is $4\,\text{m s}^{-1}$ and the speed of B is $3\,\text{m s}^{-1}$. Immediately after the collision, they move together with a speed of $3.8\,\text{m s}^{-1}$.

The mass of A is 2 kg. Find the mass of B. *(3 marks)*

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3 A car is travelling at a speed of $20\,\text{m s}^{-1}$ along a straight horizontal road. The driver applies the brakes and a constant braking force acts on the car until it comes to rest.

(a) Assume that no other horizontal forces act on the car.

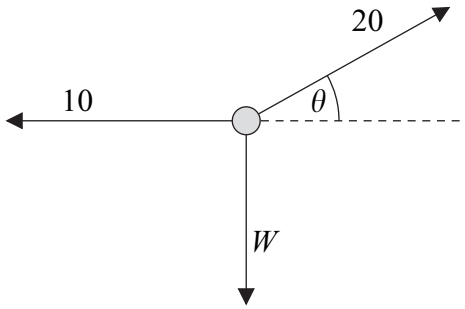
(i) After the car has travelled 75 metres, its speed has reduced to $10\,\text{m s}^{-1}$. Find the acceleration of the car. *(3 marks)*

(ii) Find the time taken for the speed of the car to reduce from $20\,\text{m s}^{-1}$ to zero. *(2 marks)*

(iii) Given that the mass of the car is 1400 kg, find the magnitude of the constant braking force. *(2 marks)*

(b) Given that a constant air resistance force of magnitude 200 N acts on the car during the motion, find the magnitude of the constant braking force. *(1 mark)*

4 A particle, of weight W newtons, is held in equilibrium by two forces of magnitudes 10 newtons and 20 newtons. The 10-newton force is horizontal and the 20-newton force acts at an angle θ above the horizontal, as shown in the diagram. All three forces act in the same vertical plane.



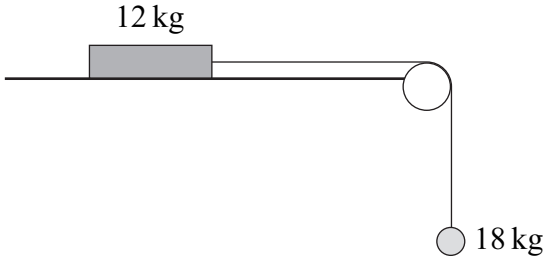
(a) Find θ. *(3 marks)*

(b) Find W. *(2 marks)*

(c) Calculate the mass of the particle. *(2 marks)*

---

5 A block, of mass 12 kg, lies on a horizontal surface. The block is attached to a particle, of mass 18 kg, by a light inextensible string which passes over a smooth fixed peg. Initially, the block is held at rest so that the string supports the particle, as shown in the diagram.



The block is then released.

(a) Assuming that the surface is smooth, use two equations of motion to find the magnitude of the acceleration of the block and particle. *(4 marks)*

(b) In reality, the surface is rough and the acceleration of the block is $3\,\text{m}\,\text{s}^{-2}$.

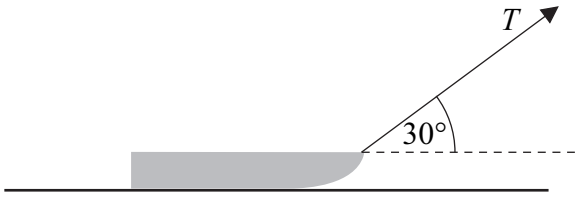
(i) Find the tension in the string. *(3 marks)*

(ii) Calculate the magnitude of the normal reaction force acting on the block. *(1 mark)*

(iii) Find the coefficient of friction between the block and the surface. *(5 marks)*

(c) State two modelling assumptions, other than those given, that you have made in answering this question. *(2 marks)*

6 A child pulls a sledge, of mass 8 kg, along a rough horizontal surface, using a light rope. The coefficient of friction between the sledge and the surface is 0.3 . The tension in the rope is T newtons. The rope is kept at an angle of 30° to the horizontal, as shown in the diagram.



Model the sledge as a particle.

(a) Draw a diagram to show all the forces acting on the sledge. *(1 mark)*

(b) Find the magnitude of the normal reaction force acting on the sledge, in terms of T. *(3 marks)*

(c) Given that the sledge accelerates at $0.05\,\text{m}\,\text{s}^{-2}$, find T. *(6 marks)*

---

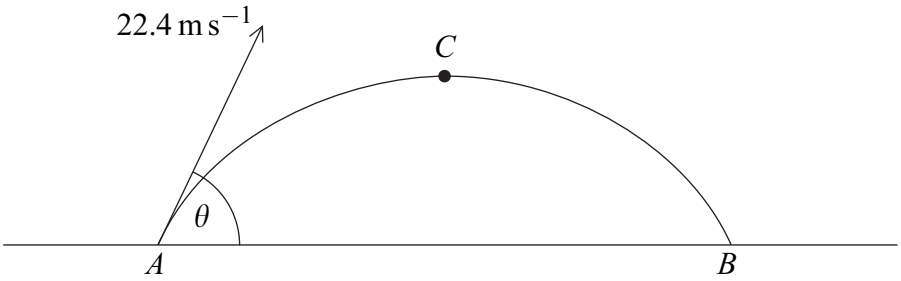
7 A particle moves with a constant acceleration of $(0.1\mathbf{i} - 0.2\mathbf{j})\,\text{m}\,\text{s}^{-2}$. It is initially at the origin where it has velocity $(-\mathbf{i} + 3\mathbf{j})\,\text{m}\,\text{s}^{-1}$. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively.

(a) Find an expression for the position vector of the particle t seconds after it has left the origin. *(2 marks)*

(b) Find the time that it takes for the particle to reach the point where it is due east of the origin. *(3 marks)*

(c) Find the speed of the particle when it is travelling south-east. *(6 marks)*

8 A particle is launched from the point A on a horizontal surface, with a velocity of $22.4\,\mathrm{m\,s^{-1}}$ at an angle θ above the horizontal, as shown in the diagram.



After 2 seconds, the particle reaches the point C, where it is at its maximum height above the surface.

(a) Show that $\sin\theta = 0.875$. *(3 marks)*

(b) Find the height of the point C above the horizontal surface. *(3 marks)*

(c) The particle returns to the surface at the point B. Find the distance between A and B. *(3 marks)*

(d) Find the length of time during which the height of the particle above the surface is greater than 5 metres. *(5 marks)*

(e) Find the minimum speed of the particle. *(2 marks)*

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
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TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2013

Mathematics MM1B

Unit Mechanics 1B

Wednesday 23 January 2013 9.00 am to 10.30 am

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

Answer **all** questions.

Answer each question in the space provided for that question.

1 A car travels on a straight horizontal race track. The car decelerates uniformly from a speed of $20\,\text{m}\,\text{s}^{-1}$ to a speed of $12\,\text{m}\,\text{s}^{-1}$ as it travels a distance of 640 metres. The car then accelerates uniformly, travelling a further 1820 metres in 70 seconds.

(a) (i) Find the time that it takes the car to travel the first 640 metres. *(3 marks)*

(ii) Find the deceleration of the car during the first 640 metres. *(3 marks)*

(b) (i) Find the acceleration of the car as it travels the further 1820 metres. *(3 marks)*

(ii) Find the speed of the car when it has completed the further 1820 metres. *(3 marks)*

(c) Find the average speed of the car as it travels the 2460 metres. *(2 marks)*

QUESTION PART REFERENCE

Answer space for question 1

Do not write outside the box

2 Three forces act on a particle. These forces are $(9\mathbf{i} - 3\mathbf{j})$ newtons, $(5\mathbf{i} + 8\mathbf{j})$ newtons and $(-7\mathbf{i} + 3\mathbf{j})$ newtons. The vectors **i** and **j** are perpendicular unit vectors.

(a) Find the resultant of these forces. *(2 marks)*

(b) Find the magnitude of the resultant force. *(2 marks)*

(c) Given that the particle has mass 5 kg, find the magnitude of the acceleration of the particle. *(2 marks)*

(d) Find the angle between the resultant force and the unit vector **i**. *(3 marks)*

QUESTION PART REFERENCE

Answer space for question 2

3 A box, of mass 3 kg, is placed on a rough slope inclined at an angle of 40° to the horizontal. It is released from rest and slides down the slope.

(a) Draw a diagram to show the forces acting on the box. *(1 mark)*

(b) Find the magnitude of the normal reaction force acting on the box. *(2 marks)*

(c) The coefficient of friction between the box and the slope is 0.2. Find the magnitude of the friction force acting on the box. *(2 marks)*

(d) Find the acceleration of the box. *(3 marks)*

(e) State an assumption that you have made about the forces acting on the box. *(1 mark)*

QUESTION PART REFERENCE

Answer space for question 3

4 A tractor, of mass 3500 kg, is used to tow a trailer, of mass 2400 kg, across a horizontal field. The trailer is connected to the tractor by a horizontal tow bar. As they move, a constant resistance force of 800 newtons acts on the trailer and a constant resistance force of R newtons acts on the tractor. A forward driving force of 2500 newtons acts on the tractor. The trailer and tractor accelerate at $0.2\,\text{m}\,\text{s}^{-2}$.

(a) Find R. *(3 marks)*

(b) Find the magnitude of the force that the tow bar exerts on the trailer. *(3 marks)*

(c) State the magnitude of the force that the tow bar exerts on the tractor. *(1 mark)*

QUESTION PART REFERENCE

Answer space for question 4

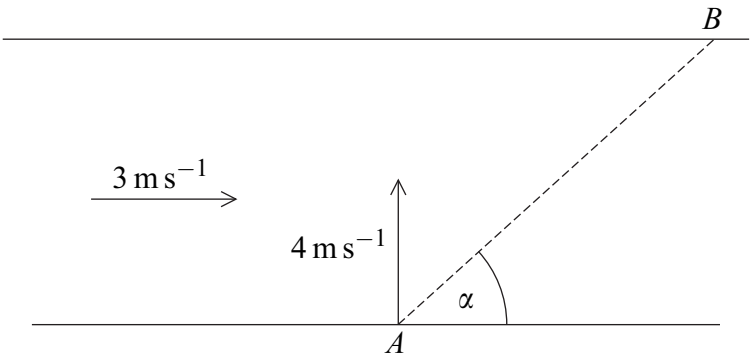
5 Two particles, A and B, are moving towards each other along the same straight horizontal line when they collide. Particle A has mass 5 kg and particle B has mass 4 kg. Just before the collision, the speed of A is $4\,\text{m s}^{-1}$ and the speed of B is $3\,\text{m s}^{-1}$. After the collision, the speed of A is $0.6\,\text{m s}^{-1}$ and both particles move on the same straight horizontal line.

Find the two possible speeds of B after the collision. *(6 marks)*

QUESTION PART REFERENCE

Answer space for question 5

6 A river has straight parallel banks. The water in the river is flowing at a constant velocity of $3\,\text{m s}^{-1}$ parallel to the banks. A boat crosses the river, from the point A to the point B, so that its path is at an angle α to the bank. The velocity of the boat relative to the water is $4\,\text{m s}^{-1}$ perpendicular to the bank. The diagram shows these velocities and the path of the boat.



(a) Show that $\alpha = 53.1°$, correct to three significant figures. *(2 marks)*

(b) The boat returns along the same straight path from B to A. Given that the speed of the boat relative to the water is still $4\,\text{m s}^{-1}$, find the magnitude of the resultant velocity of the boat on the return journey. *(6 marks)*

QUESTION PART REFERENCE

Answer space for question 6

7 A particle is initially at the point A, which has position vector $13.6\mathbf{i}$ metres, with respect to an origin O. At the point A, the particle has velocity $(6\mathbf{i} + 2.4\mathbf{j})\,\mathrm{m\,s^{-1}}$, and in its subsequent motion, it has a constant acceleration of $(-0.8\mathbf{i} + 0.1\mathbf{j})\,\mathrm{m\,s^{-2}}$. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively.

(a) Find an expression for the velocity of the particle t seconds after it leaves A. *(2 marks)*

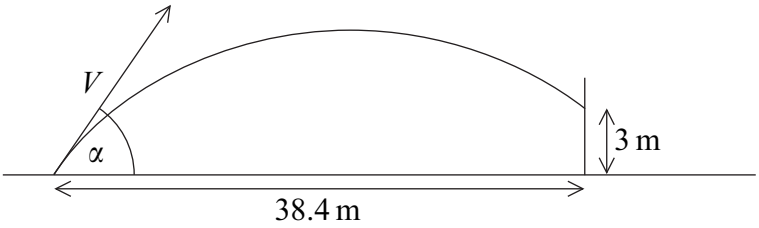
(b) Find an expression for the position vector of the particle, with respect to the origin O, t seconds after it leaves A. *(3 marks)*

(c) Find the distance of the particle from the origin O when it is travelling in a north-westerly direction. *(7 marks)*

QUESTION PART REFERENCE

Answer space for question 7

8 A golf ball is hit from a point on a horizontal surface, so that it has an initial velocity $V\,\text{m}\,\text{s}^{-1}$ at an angle α above the horizontal. The ball travels through the air and after 2.4 seconds hits a vertical wall at a height of 3 metres. The wall is at a horizontal distance of 38.4 metres from the point where the ball was hit. The path of the ball is shown in the diagram.



Assume that the weight of the ball is the only force that acts on it as it travels through the air.

(a) Find the horizontal component of the velocity of the ball. *(2 marks)*

(b) Find V. *(5 marks)*

(c) Find α. *(3 marks)*

QUESTION PART REFERENCE

Answer space for question 8

General Certificate of Education
Advanced Subsidiary Examination
June 2013

Mathematics MM1B

Unit Mechanics 1B

Friday 24 May 2013 9.00 am to 10.30 am

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

1 A toy train of mass 300 grams is moving along a straight horizontal track at a speed of $2.8\,\text{m s}^{-1}$. This toy train collides with another toy train, of mass 200 grams, which is at rest on the same track. During the collision, the two trains lock together and then move together.

Find the speed of the trains immediately after the collision. *(3 marks)*

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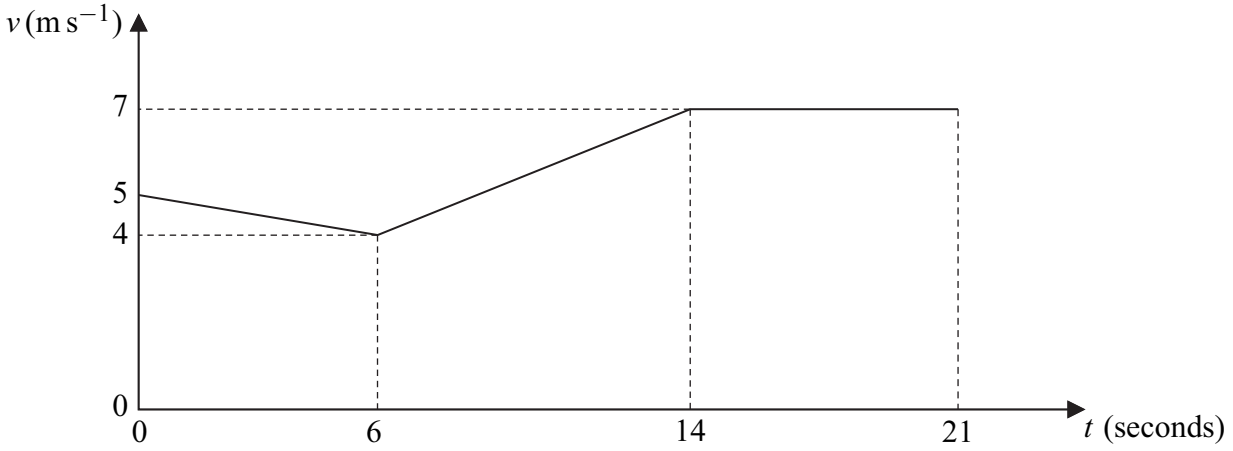
2 The graph shows how the speed of a cyclist, Hannah, varies as she travels for 21 seconds along a straight horizontal road.



(a) Find the distance travelled by Hannah in the 21 seconds. *(4 marks)*

(b) Find Hannah's average speed during the 21 seconds. *(2 marks)*

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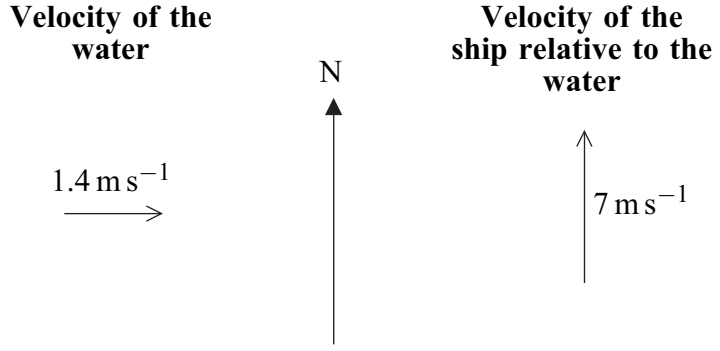
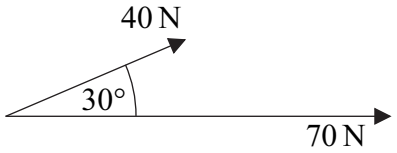
3 A ship travels through water that is moving due east at a speed of $1.4\,\text{m s}^{-1}$. The ship travels due north relative to the water at a speed of $7\,\text{m s}^{-1}$. The resultant velocity of the ship is $V\,\text{m s}^{-1}$ on a bearing α.



(a) Find V. *(2 marks)*

(b) Find α, giving your answer as a three-figure bearing, correct to the nearest degree. *(3 marks)*

4 Two forces, acting at a point, have magnitudes of 40 newtons and 70 newtons. The angle between the two forces is 30°, as shown in the diagram.



(a) Find the magnitude of the resultant of these two forces. *(4 marks)*

(b) Find the angle between the resultant force and the 70 newton force. *(3 marks)*

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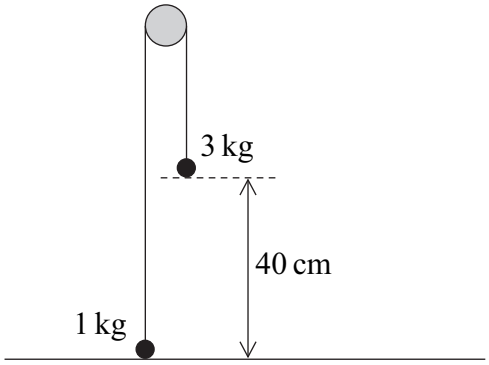
5 Two particles are connected by a light inextensible string that passes over a smooth peg. The particles have masses of 3 kg and 1 kg. The 1 kg particle is pulled down to ground level, where it is 40 cm below the level of the 3 kg particle, as shown in the diagram.



The particles are released from rest with the string vertical above each particle. Assume that no resistance forces act on the particles as they move.

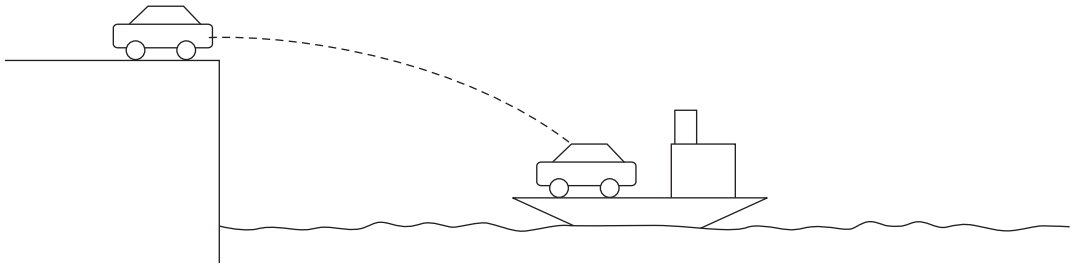
(a) By forming two equations of motion, one for each particle, find the magnitude of the acceleration of the particles after they have been released but before the 3 kg particle hits the ground. *(5 marks)*

(b) Find the speed of the 1 kg particle when the 3 kg particle hits the ground. *(2 marks)*

(c) After the 3 kg particle has hit the ground, the 1 kg particle continues to move and the string is now slack. Find the maximum height above ground level reached by the 1 kg particle. *(3 marks)*

(d) If a constant air resistance force also acts on the particles as they move, explain how this would change your answer for the acceleration in part **(a)**. Give a reason for your answer. *(2 marks)*

6 In a scene from an action movie, a car is driven off the edge of a cliff and lands on the deck of a boat in the sea, as shown in the diagram.



To land on the boat, the car must move 20 metres horizontally from the cliff. The level of the deck of the boat is 8 metres below the top of the cliff. Assume that the car is a particle which is travelling horizontally when it leaves the top of the cliff and that the car is not affected by air resistance as it moves.

(a) Find the time that it takes for the car to reach the deck of the boat. *(3 marks)*

(b) Find the speed at which the car is travelling when it leaves the top of the cliff. *(3 marks)*

(c) Find the speed of the car when it hits the deck of the boat. *(4 marks)*

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7 A block of mass 30 kg is dragged across a rough horizontal surface by a rope that is at an angle of 20° to the horizontal. The coefficient of friction between the block and the surface is 0.4 .

(a) The tension in the rope is 150 newtons.

(i) Draw a diagram to show the forces acting on the block as it moves. *(2 marks)*

(ii) Show that the magnitude of the normal reaction force on the block is 243 newtons, correct to three significant figures. *(3 marks)*

(iii) Find the magnitude of the friction force acting on the block. *(2 marks)*

(iv) Find the acceleration of the block. *(4 marks)*

(b) When the block is moving, the tension is reduced so that the block moves at a constant speed, with the angle between the rope and the horizontal unchanged. Find the tension in the rope when the block is moving at this constant speed. *(5 marks)*

(c) If the block were made to move at a greater **constant** speed, again with the angle between the rope and the horizontal unchanged, how would the tension in this case compare to the tension found in part **(b)**? *(1 mark)*

8 A helicopter travels at a constant height above the sea. It passes directly over a lighthouse with position vector $(500\mathbf{i} + 200\mathbf{j})$ metres relative to the origin, with a velocity of $(-17.5\mathbf{i} - 27\mathbf{j})\,\text{m s}^{-1}$. The helicopter moves with a constant acceleration of $(0.5\mathbf{i} + 0.6\mathbf{j})\,\text{m s}^{-2}$. The unit vectors **i** and **j** are directed east and north respectively.

(a) Find the position vector of the helicopter t seconds after it has passed over the lighthouse. *(3 marks)*

(b) The position vector of a rock is $(200\mathbf{i} - 400\mathbf{j})$ metres relative to the origin. Show that the helicopter passes directly over the rock, and state the time that it takes for the helicopter to move from the lighthouse to the rock. *(7 marks)*

(c) Find the average velocity of the helicopter as it moves from the lighthouse to the rock. *(3 marks)*

(d) Is the magnitude of the average velocity equal to the average speed of the helicopter? Give a reason for your answer. *(2 marks)*

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
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AQA

General Certificate of Education
Advanced Subsidiary Examination
June 2014

Mathematics MM1B

Unit Mechanics 1B

Monday 16 June 2014 9.00 am to 10.30 am

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
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- Do not write outside the box around each page.
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- Do all rough work in this book. Cross through any work that you do not want to be marked.
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- Take $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
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- The maximum mark for this paper is 75.

Advice
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- You do not necessarily need to use all the space provided.

Answer **all** questions.

Answer each question in the space provided for that question.

1 A car is travelling along a straight horizontal road. It is moving at $14\,\mathrm{m\,s^{-1}}$ when it starts to accelerate. It accelerates at $0.8\,\mathrm{m\,s^{-2}}$ for 12 seconds.

(a) Find the speed of the car at the end of the 12 seconds.

[3 marks]

(b) Find the distance travelled during the 12 seconds.

[3 marks]

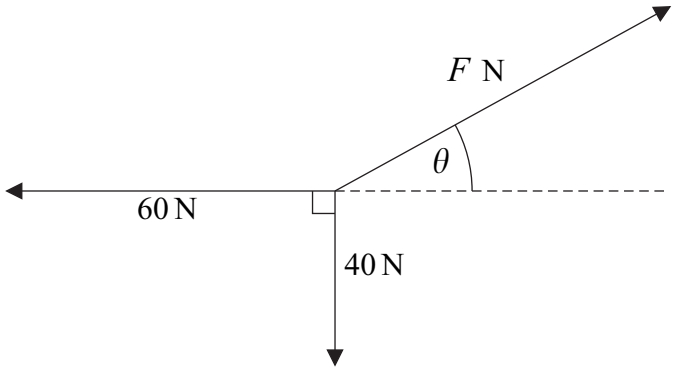
(c) The mass of the car is $1400\,\mathrm{kg}$. A horizontal forward driving force of $1600\,\mathrm{N}$ acts on the car during the 12 seconds. Find the magnitude of the resistance force that acts on the car.

[3 marks]

QUESTION PART REFERENCE

Answer space for question 1

2 Three forces are in equilibrium in a vertical plane, as shown in the diagram. There is a vertical force of magnitude $40\,\text{N}$ and a horizontal force of magnitude $60\,\text{N}$. The third force has magnitude F newtons and acts at an angle θ above the horizontal.



(a) Find F.

[2 marks]

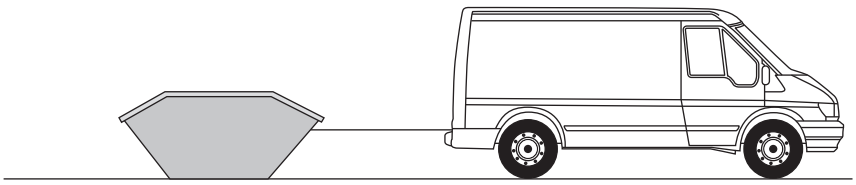
(b) Find θ.

[3 marks]

QUESTION PART REFERENCE

Answer space for question 2

3 A skip, of mass $800\,\text{kg}$, is at rest on a rough horizontal surface. The coefficient of friction between the skip and the ground is 0.4. A rope is attached to the skip and then the rope is pulled by a van so that the rope is horizontal while it is taut, as shown in the diagram.



The mass of the van is $1700\,\text{kg}$. A constant horizontal forward driving force of magnitude P newtons acts on the van. The skip and the van accelerate at $0.05\,\text{m}\,\text{s}^{-2}$.

Model both the van and the skip as particles connected by a light inextensible rope. Assume that there is no air resistance acting on the skip or on the van.

(a) Find the speed of the van and the skip when they have moved 6 metres.

[3 marks]

(b) Draw a diagram to show the forces acting on the skip while it is accelerating.

[1 mark]

(c) Draw a diagram to show the forces acting on the van while it is accelerating. State one advantage of modelling the van as a particle when considering the vertical forces.

[2 marks]

(d) Find the magnitude of the friction force acting on the skip.

[3 marks]

(e) Find the tension in the rope.

[3 marks]

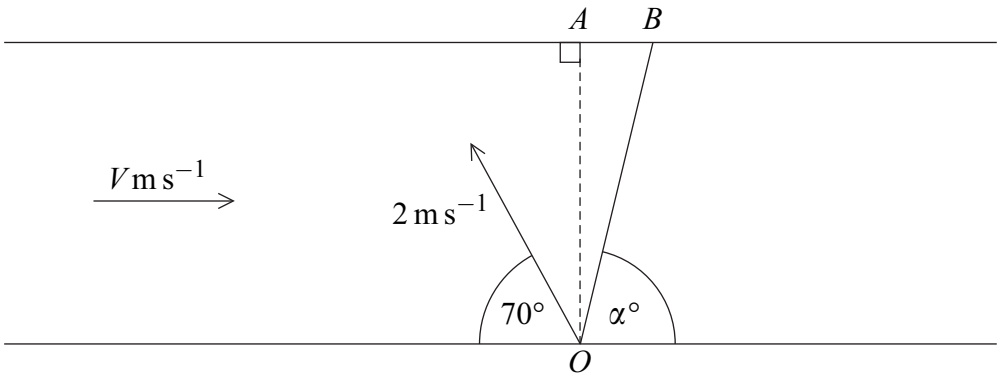
(f) Find P.

[3 marks]

QUESTION PART REFERENCE

Answer space for question 3

4 A boat is crossing a river, which has two parallel banks. The width of the river is 20 metres. The water in the river is flowing at a speed of $V\,\mathrm{m\,s^{-1}}$. The boat sets off from the point O on one bank. The point A is directly opposite O on the other bank. The velocity of the boat relative to the water is $2\,\mathrm{m\,s^{-1}}$ at an angle of $70°$ to the bank. The boat lands at the point B which is 3 metres from A. The angle between the actual path of the boat and the bank is $\alpha°$. The river and the velocities are shown in the diagram.



(a) Find the time that it takes for the boat to cross the river.

[3 marks]

(b) Find α.

[2 marks]

(c) Find V.

[5 marks]

QUESTION PART REFERENCE

Answer space for question 4

5 Two particles, A and B, have masses of m and km respectively, where k is a constant. The particles are moving on a smooth horizontal plane when they collide and coalesce to form a single particle. Just before the collision the velocities of A and B are $(4\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-1}}$ and $(6\mathbf{i} - 2\mathbf{j})\,\mathrm{m\,s^{-1}}$ respectively. Immediately after the collision the combined particle has velocity $(5.2\mathbf{i} - 0.4\mathbf{j})\,\mathrm{m\,s^{-1}}$.

Find k.

[5 marks]

QUESTION PART REFERENCE

Answer space for question 5

6 A bullet is fired from a rifle at a target, which is at a distance of 420 metres from the rifle. The bullet leaves the rifle travelling at $V\,\mathrm{m\,s^{-1}}$ and at an angle of $2°$ above the horizontal. The centre of the target, C, is at the same horizontal level as the rifle. The bullet hits the target at the point A, which is on a vertical line through C. The bullet takes 1.8 seconds to reach the point A.

(a) Find V, showing clearly how you obtain your answer.

[3 marks]

(b) Find the distance between A and C.

[4 marks]

(c) State one assumption that you have made about the forces acting on the bullet.

[1 mark]

QUESTION PART REFERENCE

Answer space for question 6

Do not write outside the box

7 Two particles, A and B, move on a horizontal surface with constant accelerations of $-0.4\mathbf{i}\,\mathrm{m\,s^{-2}}$ and $0.2\mathbf{j}\,\mathrm{m\,s^{-2}}$ respectively. At time $t = 0$, particle A starts at the origin with velocity $(4\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. At time $t = 0$, particle B starts at the point with position vector $11.2\mathbf{i}$ metres, with velocity $(0.4\mathbf{i} + 0.6\mathbf{j})\,\mathrm{m\,s^{-1}}$.

(a) Find the position vector of A, 10 seconds after it leaves the origin.

[2 marks]

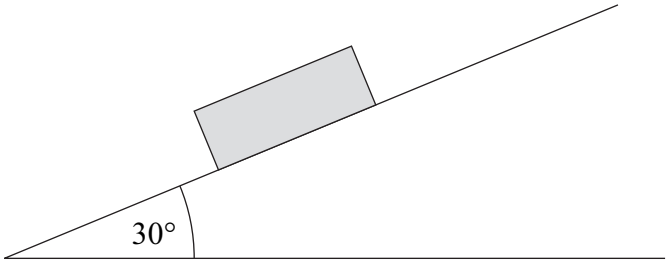
(b) Show that the two particles collide, and find the position vector of the point where they collide.

[9 marks]

QUESTION PART REFERENCE

Answer space for question 7

8 A crate, of mass $40\,\text{kg}$, is initially at rest on a rough slope inclined at $30°$ to the horizontal, as shown in the diagram.

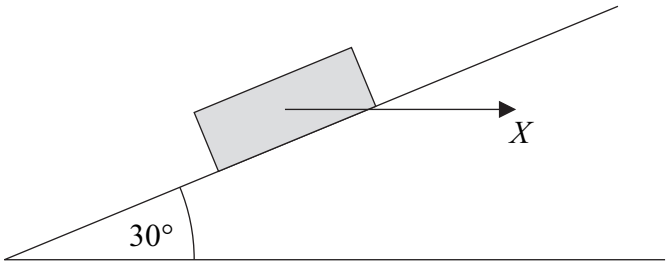


The coefficient of friction between the crate and the slope is μ.

(a) Given that the crate is on the point of slipping down the slope, find μ.

[5 marks]

(b) A horizontal force of magnitude X newtons is now applied to the crate, as shown in the diagram.



(i) Find the normal reaction on the crate in terms of X.

[2 marks]

(ii) Given that the crate accelerates up the slope at $0.2\,\text{m}\,\text{s}^{-2}$, find X.

[5 marks]

QUESTION PART REFERENCE

Answer space for question 8

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	

AQA

General Certificate of Education
Advanced Subsidiary Examination
June 2015

Mathematics MM1B

Unit Mechanics 1B

Friday 12 June 2015 9.00 am to 10.30 am

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\,\mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

Answer **all** questions.

Answer each question in the space provided for that question.

1 A child, of mass $48\,\text{kg}$, is initially standing at rest on a stationary skateboard. The child jumps off the skateboard and initially moves **horizontally** with a speed of $1.2\,\text{m s}^{-1}$. The skateboard moves with a speed of $16\,\text{m s}^{-1}$ in the opposite direction to the direction of motion of the child. Find the mass of the skateboard.

[3 marks]

QUESTION PART REFERENCE

Answer space for question 1

Do not write outside the box

2 A yacht is sailing through water that is flowing due west at $2\,\mathrm{m\,s^{-1}}$. The velocity of the yacht relative to the water is $6\,\mathrm{m\,s^{-1}}$ due south. The yacht has a resultant velocity of $V\,\mathrm{m\,s^{-1}}$ on a bearing of θ.

(a) Find V.

[2 marks]

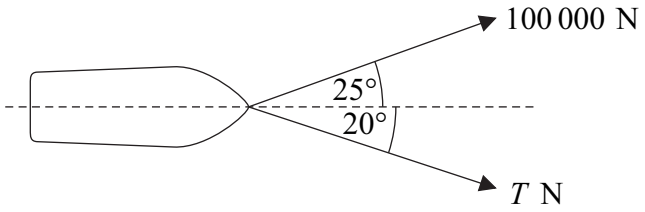
(b) Find θ, giving your answer to the nearest degree.

[3 marks]

QUESTION PART REFERENCE

Answer space for question 2

3 A ship has a mass of 500 tonnes. Two tugs are used to pull the ship using cables that are horizontal. One tug exerts a force of $100\,000$ N at an angle of $25°$ to the centre line of the ship. The other tug exerts a force of T N at an angle of $20°$ to the centre line of the ship. The diagram shows the ship and forces as viewed from above.



The ship accelerates in a straight line along its centre line.

(a) Find T.

[3 marks]

(b) A resistance force of magnitude $20\,000$ N directly opposes the motion of the ship. Find the acceleration of the ship.

[4 marks]

QUESTION PART REFERENCE

Answer space for question 3

4 A particle moves with constant acceleration between the points A and B. At A, it has velocity $(4\mathbf{i} + 2\mathbf{j})\,\mathrm{m\,s^{-1}}$. At B, it has velocity $(7\mathbf{i} + 6\mathbf{j})\,\mathrm{m\,s^{-1}}$. It takes 10 seconds to move from A to B.

(a) Find the acceleration of the particle.

[3 marks]

(b) Find the distance between A and B.

[5 marks]

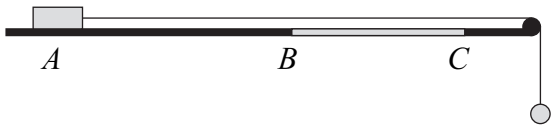
(c) Find the average velocity as the particle moves from A to B.

[2 marks]

QUESTION PART REFERENCE

Answer space for question 4

5 A block, of mass $3m$, is placed on a horizontal surface at a point A. A light inextensible string is attached to the block and passes over a smooth peg. The string is horizontal between the block and the peg. A particle, of mass $2m$, is attached to the other end of the string. The block is released from rest with the string taut and the string between the peg and the particle vertical, as shown in the diagram.



Assume that there is no air resistance acting on either the block or the particle, and that the size of the block is negligible.

The horizontal surface is smooth between the points A and B, but rough between the points B and C. Between B and C, the coefficient of friction between the block and the surface is 0.8.

(a) By forming equations of motion for both the block and the particle, find the acceleration of the block between A and B.

[4 marks]

(b) Given that the distance between the points A and B is 1.2 metres, find the speed of the block when it reaches B.

[3 marks]

(c) By forming equations of motion for both the block and the particle, find the acceleration of the block between B and C.

[5 marks]

(d) Given that the distance between the points B and C is 0.9 metres, find the speed of the block when it reaches C.

[3 marks]

(e) Explain why it is important to assume that the size of the block is negligible.

[1 mark]

QUESTION PART REFERENCE

Answer space for question 5

6 Emma is in a park with her dog, Roxy. Emma throws a ball and Roxy catches it in her mouth. The ground in the park is horizontal. Emma throws the ball from a point at a height of 1.2 metres above the ground and Roxy catches the ball when it is at a height of 0.5 metres above the ground. Emma throws the ball with an initial velocity of $8\,\mathrm{m\,s^{-1}}$ at an angle of $30°$ above the horizontal.

(a) Find the time that the ball takes to travel from Emma's hand to Roxy's mouth.

[5 marks]

(b) Find the horizontal distance travelled by the ball during its flight.

[2 marks]

(c) During the flight, the speed of the ball is a maximum when it is at a height of h metres above the ground. Write down the value of h.

[1 mark]

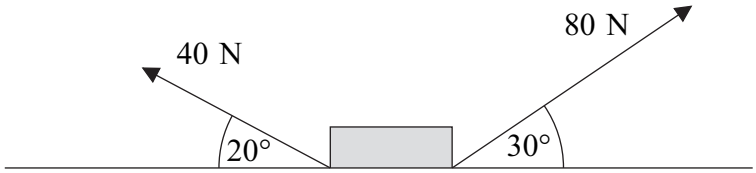
(d) Find the maximum speed of the ball during its flight.

[4 marks]

QUESTION PART REFERENCE

Answer space for question 6

7 Two forces, which act in a vertical plane, are applied to a crate. The crate has mass $50\,\text{kg}$, and is initially at rest on a rough horizontal surface. One force has magnitude $80\ \text{N}$ and acts at an angle of $30°$ to the horizontal and the other has magnitude $40\ \text{N}$ and acts at an angle of $20°$ to the horizontal. The forces are shown in the diagram.



The coefficient of friction between the crate and the surface is 0.6.

Model the crate as a particle.

(a) Draw a diagram to show the forces acting on the crate.

[2 marks]

(b) Find the magnitude of the normal reaction force acting on the crate.

[3 marks]

(c) Does the crate start to move when the two forces are applied to the crate? Show all your working.

[5 marks]

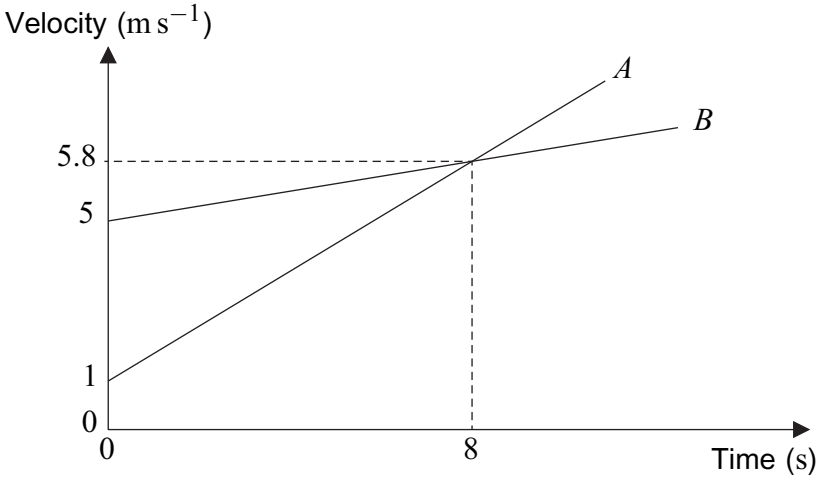
(d) State one aspect of the possible motion of the crate that is ignored by modelling it as a particle.

[1 mark]

QUESTION PART REFERENCE

Answer space for question 7

8 Two trains, A and B, are moving on straight horizontal tracks which run alongside each other and are parallel. The trains both move with constant acceleration. At time $t = 0$, the fronts of the trains pass a signal. The velocities of the trains are shown in the graph below.



(a) Find the distance between the fronts of the two trains when they have the same velocity and state which train has travelled further from the signal.

[3 marks]

(b) Find the time when A has travelled 9 metres further than B.

[8 marks]

QUESTION PART REFERENCE

Answer space for question 8